HANDBOOK FOR

SEAMAN GUNNERS

CATECHISM OF WHITEHEAD TORPEDOES, NAVAL DEFENSE MINE COUNTERMINE, OBSERVATION MINE EXPLOSIVES, AND ELECTRICITY

PREPARED AT THE UNITED STATES NAVAL TORPEDO STATION
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WHITEHEAD TORPEDOES, MARKS, I, II, III, 3.55 M. BY 45 CM. AND THE 5 M. BY 45 CM. MARKS, I AND II, WITH THE GYRO GEAR AND ITS ADJUSTMENTS.

CHAPTER I.

WHITEHEAD TORPEDOES.

QUESTION.	ANSWER.
1. How many marks of Whitehead torpedoes are there in the service?	Five.
2. Name them.	The 3.55m. by 45cm., Marks I, II, III, and the 5m. by 45cm., Marks I and II.
3. What does the Whitehead torpedo consist of?	It consists of a cylindrical air flask, to which is attached an ogival head and a conical after-body bearing the tail.
4. How many heads are there?	Two.
5. Name them.	The war and exercise heads.
6. What is the war head made of ?	Bronze.
7. What is the exercise head made of?	Sheet steel.
8. What does the war head contain?	The explosive charge for use in action.
9. What does the exercise head contain?	Fresh-water ballast for use in exercise.
10. What is the air flask made of?	Steel.
11. What does the air flask contain?	Compressed air, the motive power of the torpedo.
12. What is the after-body made of?	Steel.
13. What does the after-body contain?	The engine and the controlling mechanism.
14. What is the tail made of?	Steel.
15. What does the tail carry?	Propellers and rudders.
16. At what pressure is the air in the air flask compressed to?	At a pressure of 1,350 pounds per square inch, or 90 atmospheres, except in the 5m., Mark II, which is 1,500 pounds per square inch, or 100 atmospheres.

WHITEHEAD TORPEDOES—Continued.

Question.	Answer.
17. How is the torpedo launched from the tube?	By air or gunpowder impulse.
18. What is the length of the 3.55 m. by 45cm., Mark I, torpedo?	11 feet 8 inches.
19. What is its greatest diameter?	17.7 inches.
20. What is the capacity of the air flask?	7.154 cubic feet.
21. What is the weight of air charge at 62° F., at a compression of 1,350 pounds per square inch?	50 pounds.
22. What is the weight of charge in war head?	94.8 pounds dry gun cotton plus 25 per cent of water, making a total weight of 118½ pounds wet gun cotton.
23. What is the displacement of torpedo in sea water, sp. gr. 1.026 at 62° F.?	838 pounds.
24. What is the weight of the torpedo with air flask charged to 1,350 pounds per square inch and war head attached ready for launching?	845 pounds.
25. What is the negative buoyancy of the same in sea water?	7 pounds.
26. What is the reserve buoyancy of same in sea water with pressure in air flask reduced to 1,050 pounds per square inch?	4 pounds.
27. What is the weight of torpedo with air flask charged to 1,350 pounds per square inch and exercise head attached, ballasted with fresh water?	836 pounds.
28. What is the reserve buoyancy of same in sea water?	2 pounds.
29. How many parts is the torpedo constructed in?	Five.

WHITEHEAD TORPEDOES—Continued.

Question.	Answer.
30. Name them.	The head, air flask, immersion chamber, after-body, and tail.
31. How many parts is the torpedo ordinarily assembled and disassembled?	Three.
32. Name them.	The head, air flask, and after-body.

THE WAR HEAD.

33. How many heads are furnished with each torpedo?	Two.
34. What are they?	The war and exercise heads.
35. What are these heads used for?	War and exercise, use, respectively.
36. What are they secured to?	Forward end of air flask.
37. By what means?	Twelve joint screws.
38. How is the base of the war head closed?	By a bronze bulkhead.
39. How is the bulkhead secured?	By screws to a stiff joint ring of bronze in the after end of the head against a rubber washer.
40. Why is a moisture tap placed in the bulkhead?	For the purpose of pouring water in when necessary to make up possible loss of weight in charge due to evaporation.
41. Where is the stowage weight of the war head stamped?	On the bulkhead near the moisture tap.
42. Where is the primer case secured in the war head?	In the forward end.
43. By what means?	Soldered.
44. What is the primer case made of?	Brass.
45. What is the primer case for?	For inserting the dry gun-cotton primers when priming the torpedo.
46. Why is the primer case recessed and threaded?	For the reception of the war nose.

WHITEHEAD TORPEDOES—Continued.

THE WAR NOSE.

Question.	Answer.
47. What is the use of the war nose?	To explode a detonator containing 35 grains of fulminate of mercury, which in turn detonates the dry gun-cotton primer then the wet gun cotton in the head.
48. Where is the war nose placed?	It is screwed in the forward end of the primer case in the war head.
49. What does the war nose consist of?	The exploder, the mechanism for firing it on impact of the torpedo with the target, and the safety mechanism by which the firing mechanism is rendered inactive until, after launching, the torpedo shall have traveled through the water a safe distance from the point of launching.
50. What is the body of the war nose made of?	Bronze.
51. What is the firing pin made of?	Steel.
52. What motion has the firing pin within the body of the war nose?	Longitudinal.
53. How is the firing pin held in place with its point clear of the percussion cap of the exploder?	By a shearing pin, passed through holes in the body of the war nose and of the firing pin.
54. What is the sheering pin made of?	Pure tin.
55. What is the shearing pin for?	To keep the firing pin from being driven in by the rush through the water or by impact with light articles in the path of the torpedo before the target is reached.
56. What is in the body of the war nose forward of the firing pin?	Traveling sleeve.
57. What is the traveling sleeve made of?	Steel.
58. What motion is it capable of?	Longitudinal motion to the extent allowed by the screw entering the limiting slot.
59. How is the traveling sleeve threaded?	Inside throughout its length.
60. What travels in this thread?	Traveling nut.
61. What kind of a hole has the traveling nut in its center?	Square.

WHITEHEAD TORPEDOES—Continued.

THE WAR NOSE—Continued.

Question.	Answer.
62. What passes through this square hole?	Square shaft of the screw fan.
63. What is the screw fan and shaft made of?	Steel.
64. What movement has the shaft of the screw fan in the traveling sleeve?	Freedom of revolution.
65. How is the shaft of the screw fan retained in the traveling sleeve?	By a screw, whose inner end projects between two collars on the forward end of the shaft.
66. During the passage of the torpedo through the water what does the square shaft of the screw fan first do?	It causes the traveling nut to run aft in the traveling sleeve until it bears against the forward end of the firing pin.
67. What prevents it from going farther aft?	The resistance opposed by the shearing pin.
68. Where is the movement then shifted to?	To the traveling sleeve.
69. Which way does it move?	Forward.
70. What limits its forward movement?	Limiting slot.
71. In what position is the war nose now in?	For firing.
72. How is this done?	Upon impact of the screw fan with the target the traveling sleeve and nut is forced aft against the firing pin, shearing the shearing pin and driving the firing pin against the percussion cap of the exploder.
73. When is the war nose in position of safety?	When the traveling nut is run forward to its full limit in the traveling sleeve.
74. How is this done?	By revolving the screw fan in the direction of the arrow stamped on the body of the war nose until stopped by the contact of the two stop pins.
75. Where are the two stop pins?	One on the forward end of the traveling nut and the other on the forward end of the traveling sleeve.
76. How many yards will the torpedo have to run before the traveling nut presses upon the head of the firing pin?	Forty-five yards.

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WHITEHEAD TORPEDOES—Continued.

THE WAR NOSE—Continued.

Question.	Answer.
77. How many revolutions will the screw fan have made?	Thirteen revolutions.
78. How many yards will the torpedo run from the time the traveling nut presses upon the head of the firing pin until the traveling sleeve is in its forward position?	Twenty-four yards.
79. How many revolutions will the screw fan have made during the latter run?	Seven revolutions.
80. How far will the torpedo have to run before the war nose can be exploded by contact?	Sixty-nine yards.
81. What do the holes in the body of the war nose in rear of the firing pin permit and avoid?	Free escape of water and cushioning.
82. What prevents the entrance of water to the primer around and through the war nose?	Porpoise-hide washer interposed between the torpedo head and the shoulder of the war nose and a copper disk 0.003 of an inch thick soldered water-tight in the base of the war nose over the hole through which the firing pin passes.

THE EXERCISE HEAD.

83. How is the exercise head ballasted?	By filling it with fresh water.
84. How is it closed at its after end?	By a bulkhead secured by screws to a stiff joint ring of bronze against a rubber washer.
85. What is carried in its forward end?	Primer case.
86. What use is made of the primer case in this head?	The depth or rolling register is screwed in against a rubber washer when the torpedo is to be tested for rolling or diving.
87. What else can be put in the primer case?	The exercise nose.
88. What use is made of it?	It is used to hitch the nose line for towing the torpedo.

WHITEHEAD TORPEDOES—Continued.

THE AIR FLASK.

Question.	Answer.
89. What is the shape of the heads of the air flask and how are they secured?	Dome shaped, and are screwed and soldered in each end.
90. How is the air flask strengthened?	By a strengthening band left on the inside surface in boring.
91. What is secured to the strengthening band on the outside of the flask?	Guide stud.
92. Where are the bodies of the charging and stop valves?	Over a hole in the after head of the air flask.
93. How are they secured?	Bolted and soldered.

THE IMMERSION CHAMBER.

94. What is the immersion chamber?	A short truncated cone of steel, riveted and soldered to the after end of the air flask and closed at its after end by a bronze bulkhead.
95. How and where is it strengthened?	At its middle part by a strengthening ring inside and by a stout joint ring of bronze at its after end.
96. Where and how is its bulkhead secured?	To the joint ring, against a rubber washer, by screw bolts and nuts.
97. What does the immersion chamber contain?	The charging and stop valves and the immersion mechanism.
98. How is the immersion chamber drained?	By drain holes closed by a screw plugs.

CHARGING AND STOP VALVES.

99. How and of what are the bodies of these valves made?	They are cast in one piece and are made of bronze.
100. Where are the valves situated?	In the forward part of the immersion chamber.
101. From where are they accessible?	From the outside.
102. What is the charging valve for?	For connecting the air pipe to charge the flask with air.

WHITEHEAD TORPEDOES—Continued.

CHARGING AND STOP VALVES—Continued.

Question.	Answer.
103. What does the charging valve consist of?	The charging-valve plug, the charging valve, the charging-valve seat, the check valve, and spring.
104. What is placed between the charging valve and the shoulder of its seat?	Porpoise-hide washer.
105. How is the check valve made air-tight and held in its seat?	Ground in and held in its seat by a spring.
106. When the charging-valve plug is removed and the wing nut screwed in its place, how is the check valve unseated?	A rib on the bottom of the wing nut forces it down against its spring.
107. What is the function of the check valve when the wing nut is unscrewed?	The check valve is forced up into its seat by its spring, which prevents any loss of air.
108. What is the stop valve used for?	To close the flask after it is charged and until it is placed in the tube for launching.
109. What does it consist of?	The carrier, the stop valve, the stop-valve plug, the follower, and operating spindle.
110. What is placed between the head of the stop-valve plug and the collar on the spindle?	Porpoise-hide washer.
111. What kind of a joint does the stop valve make in its seat?	Ground joint.
112. What is the function when the spindle is turned?	Turning the spindle screws the carrier down or up, seating or lifting the valve.
113. How is the air conveyed from the air flask to the engine?	Via the reducing valve in the valve group and a copper pipe leading from the body of the stop valve above its seat.

THE IMMERSION MECHANISM.

114. What does this mechanism consist of?	The hydrostatic piston, the depth index, and the pendulum.
115. What does the hydrostatic piston govern?	Immersion of the torpedo during the run.

WHITEHEAD TORPEDOES—Continued.

THE IMMERSION MECHANISM—Continued.

Question.	Answer.
116. What does the pendulum govern?	It acts to maintain the torpedo in the horizontal plane.
117. How is the combined action of the hydrostatic piston and pendulum transmitted to the steering engine?	Through the system of levers and connecting rods.

THE HYDROSTATIC PISTON.

118. What and where is this piston?	It is a metal disk and is contained in a shallow circular recess cast in the center of the bulkhead.
119. How is the after side of the recess closed?	By a rubber diaphragm.
120. What does it permit?	Water pressure to act on the after side of the hydrostatic piston.
121. How is the rim of the diaphragm made air and water tight?	By a bronze ring secured by screw bolts and nuts.
122. What bears on the forward side of the piston?	Spiral compression spring.
123. Where is it carried?	Between two sliding spring boxes in a bronze tube cast on the forward side of the bulkhead.
124. What is the function of the after spring box?	It transmits the thrust of the spring to the piston.
125. What is the forward spring box fitted with?	Two lugs which project through the longitudinal slots in the sides of the tube.
126. What bears on the forward side of these two lugs?	The lower fork of the forked bell crank.
127. What is the function of the forked bell crank?	It is a medium by which the compression of the spring may be varied at will by adjusting the depth index.
128. To what is the motion of the hydrostatic piston transmitted?	Steering-engine valve rod.
129. Name the connections through which this movement is transmitted.	The hydrostatic-piston lever, the upper connecting rod and sleeve, the cross lever, the lower connecting rod and sleeve, the rock shaft, and the locking jaws.

WHITEHEAD TORPEDOES—Continued.

THE HYDROSTATIC PISTON—Continued.

QUESTION.	ANSWER.
130. How are the connecting rods and sleeves made elastic?	By the interposition of a spiral spring in each sleeve.
131. What is this for?	To prevent sudden shocks from straining the system of levers and to take up the movement of the hydrostatic piston and pendulum when the steering-engine valve rod is locked.
132. What transmits the motion of the system of levers through the bulkhead?	The rock shaft in the air and water tight stuffing box, which is bolted to the forward side of the bulkhead against a washer of thick paper.
133. How is the rock shaft fitted and connected.	It has two arms, one outside the stuffing box, connected with the lower connecting rod and sleeve, and the other inside the stuffing box, connected with the steering-engine valve rod by the locking jaws.

THE DEPTH INDEX.

QUESTION.	ANSWER.
134. How is the immersion of the torpedo controlled during its run?	By the adjustments of the depth index.
135. Where is the head of the spindle accessible from?	Outside shell of the torpedo.
136. What is the shape of its shank, and where does the shank fit?	It is square and fits in the head of the adjusting screw.
137. How is the lower end of the adjusting screw supported?	By the socket post.
138. What does the adjusting screw pass through?	The adjusting nut.
139. What has the adjusting nut, and what bears upon it?	A collar upon which bears the upper fork of the forked bell crank.
140. When the spindle and adjusting screw are turned, what takes place?	The adjusting nut is moved along the adjusting screw, raising or lowering the upper fork of the bell crank and causing its lower fork to compress, more or less, the compression spring against the forward face of the hydrostatic piston.
141. What effect does the compression of the hydrostatic-piston spring have on the piston?	The greater the compression the greater the force opposing the water pressure on the after face of the hydrostatic piston and, consequently, the greater the immersion of the torpedo before the hydrostatic piston will be in equilibrium between these opposing forces.

WHITEHEAD TORPEDOES—Continued.

THE DEPTH INDEX—Continued.

Question.	Answer.
142. What will be the position of the rudder when this equilibrium is attained?	Slightly down, steering the torpedo in the horizontal plane against its buoyancy, which tends to make it rise.
143. Where is the index sleeve visible from?	Outside shell.
144. Where is the index sleeve graduated?	On its upper face for feet of immersion.
145. How is it geared to the spindle?	Differentially.
146. How is it retained in place within the body inclosing the gears?	By a gland screwed over it.
147. When the spindle is turned, in making the adjustment for immersion, what takes place?	The index sleeve revolves, showing by the coincidence of its graduations with a fore and aft line stamped on the shell the depth at which the torpedo will run.
148. What is done after the adjustment is made?	The clamp nut is screwed down.
149. What does the clamp nut do when it is screwed down?	Clamps the depth index and makes a water-tight joint.
150. How does it make a water-tight joint?	By forcing down the spindle against a porpoise-hide washer interposed between its shoulder and the inclosing body, which is riveted and soldered to the shell of the torpedo inside.
151. In assembling the torpedo, what depth is the reference point set for?	5-foot immersion.
152. How is it accomplished?	The adjusting screw is turned until the after edge of the shoulder of the forward spring box in the tube coincides with a line cut on the side of the tube marked 5, which gives the compression of the spring, that will balance the water pressure on the after side of the hydrostatic piston at a depth of 5 feet.
153. How is the depth index put in its place?	With the mark 5 on its face corresponding with the fore and and aft line on the shell of the torpedo.
154. Starting from the 5-foot mark, what adjustments can be made?	Any depth desired up to 20 feet.
155. How?	By turning the spindle with a socket wrench inserted from outside the shell of the torpedo.

WHITEHEAD TORPEDOES—Continued.

THE PENDULUM.

Question.	Answer.
156. Where are the pendulum supports secured?	To the forward side of the bulkhead.
157. What do they suspend?	The pendulum bob.
158. How does the pendulum swing?	In the vertical plane passing through the axis of the torpedo.
159. Where is the pendulum guide secured, and what does it pass between?	Secured to the bulkhead, and passes between the pendulum rods.
160. What does it keep the pendulum from doing?	From swinging in the thwartship direction.
161. What passes through the brace, joining the pendulum rod?	The checking spring rod.
162. Where is it hinged?	To the bulkhead.
163. What do the checking-spring rods carry?	The compression checking springs, the inner ends of which bear against the pendulum brace, and the outer ends against the checking-spring nuts.
164. What use is made of the checking-spring nuts?	The compression of the checking springs may be varied to check the sensitiveness of the pendulum, retaining it from swinging in either direction until the axis of the torpedo shall have become inclined a small angular distance from the horizontal plane.
165. What is the angular adjustment usually made of the checking-springs?	The pendulum is prevented from swinging within an angle of inclination of the axis of the torpedo of from 3° above to 3° below the horizontal plane.
166. What governs the torpedo within these small limits?	The hydrostatic piston.
167. How is the motion of the pendulum transmitted to the steering engine valve rod?	By the cross lever pivoted on the port pendulum rod, the lower connecting rod and sleeve, rock shaft, and the locking jaws.
168. What limits the total swing of the pendulum?	The bulkhead abaft it, the strengthening ring and buffer bracket forward of it.
169. What eases the shock of the blows of the pendulum?	Spring buffers.
170. How is the pendulum secured when the torpedo is in transportation?	A transportation screw is put in place of the screw plug in the drain hole under the pendulum.

WHITEHEAD TORPEDOES—Continued.

THE AFTER BODY.

Question.	Answer.
171. Where is the after body secured?	To the after end of the immersion chamber by 18 joint screws.
172. Where and how is the after body stiffened?	At its forward end by the engine-room cage, a stout frame of bronze, riveted and soldered to the inside of the shell of the torpedo throughout the length of the engine room; at its after end by the forward half of the bevel gear box of bronze, riveted and soldered to the shell of the torpedo, and at equal distances between by two interior strengthening rings.
173. What does the forward part of the after body contain?	The engine room.
174. What does the engine room contain?	The main engine, the engine oil cup, the valve group, the sinking and retarding gear, the steering engine. and locking gear.
175. What does the after part of the after body contain?	The main shaft, within the shaft tube and the steering rod within the steering tube.
176. How is the after body made water-tight?	By a rubber washer between the engine bed plate and the after end of the engine-room cage, a rubber washer between the tube flanges of the tube and the forward face of the bevel gear box.
177. What does the after body carry?	The tail.

THE ENGINE.

178. What kind of an engine is the Whitehead?	Single acting.
179. How many cylinders?	Three.
180. What is the body made of?	Phosphor bronze.
181. What does it comprise in one casting?	The cylinders, the valve chests and air passages, and the crank case.
182. Where is the engine secured?	To the bedplate.
183. How?	Bolted by 6 holding screws.
184. How do the 3 cylinders radiate from the crank case?	In the transverse vertical plane.
185. How far are their axes apart?	120 degrees.
186. What is cast on the forward side of each cylinder?	The valve chest.

WHITEHEAD TORPEDOES—Continued.

THE ENGINE—Continued.

Question.	Answer.
187. Whose axis is the valve chest parallel with?	The cylinder.
188. Where does the inner ends of the cylinders and valve chest open into?	The crank case.
189. How is the forward end of the crank case closed?	By the crank-case cover.
190. What is the crank-case cover, and its use?	A screw plate of bronze, which takes the thrust of the forward end of the main shaft, which butts in a socket cast in the center of the cover.
191. What prevents the cover from jarring out?	A locking strip and screw on its forward face.
192. What is the after end of the crank case cast in one with?	The body.
193. Why has it an opening through its center?	For a short sleeve.
194. What does this sleeve serve as?	Bearing for the main shaft abaft the crank.
195. What is forward of the crank?	A round or wheel bearing of bronze.
196. What does it slip on over?	Main shaft.
197. Where are the after bearings of the shaft?	In the after end of the shaft tube and in the tail tube.
198. How and what is the main shaft made of?	It is hollow and made of bronze.
199. What does it carry on its after end?	The after propeller.
200. Where is the forward propeller carried?	On the outer tubular shaft.
201. What is the pitch of the propellers?	Forward propeller left-handed, after propeller right-handed.
202. How is the outer tubular shaft geared to the main shaft?	By the gears in the gear box in the tail of the torpedo.
203. How are the pistons packed?	By bronze piston rings.
204. Where and how are the connecting rods attached?	To the inner side of the piston by a ball-and-socket joint.

WHITEHEAD TORPEDOES—Continued.

THE ENGINE—Continued.

Question.	Answer.
205. Where and how are the inner ends of the connecting rod secured?	To the socket of its crank-pin brass by a screw pin which carries a small pin drilled in its head at right angles to its length.
206. What is this pin for?	This pin comes against a small safety screw tapped in the crank-pin brass, preventing the screw pin being jarred out.
207. What angle does the crank-pin brasses embrace the crank pin?	Through about 90° of arc.
208. Where and how are the crank-pin brasses held in place?	In an annular groove cut in the end of each arm of the crank concentric with the crank pin, the ends of the brasses being finished with tongues to fit the grooves.
209. What permits sliding the brasses on or off the crank pin?	A gate cut in the outer arm of the forward crank.
210. How is the gate closed when the brasses are in place?	By a small removable brass piece held by a screw.
211. From where is this screw accessible?	Through a hole in the crank case, closed by a screw plug.
212. How is the crank balanced?	By a counterpoise opposite each arm forged in one body with the crank.
213. What is the passage of air from the flask through the valve group and to the valve chest?	Air from the flask passes through air pipes by way of the reducing valve in the valve group to an interior annular channel cast in the periphery of the forward end of the crank case and is conveyed from this annular channel to the outer end of each valve chest by the air passage cast on the forward side of each valve chest.
214. What kind of valves are the main valves?	Piston valves.
215. How many are there?	Three.
216. What motion do they have in the valve chest?	Longitudinal motion.
217. From what do the valves receive their motion?	From the cam keyed on the main shaft.
218. Where and how do the valve rods ship?	The outer end of each valve rod ships in a socket in the inner end of the valve stem, and the inner end of the valve rod carries a roll which bears on the cam with a constant push, due to the air pressure on the outer face of the valve.

WHITEHEAD TORPEDOES—Continued.

THE ENGINE—Continued.

Question.	Answer.
219. What do the valve stems slide in?	In circular guides, which are attached to the valve chest ribs, the guides and ribs being cast in one with the valve chest.
220. What does the spaces between the ribs allow?	The passage of exhaust air to the crank case.
221. What does the inner ends of the valve rods slide in?	Circular guides cast in the ring guide for valves, which is secured inside the crank case by screws, screwed in from the outside.
222. Where is the cam for valves secured?	It is keyed to the main shaft and revolves with it.
223. What kind of a cam is it?	A disk cam of three principal curves.
224. How is it held in place?	By the eccentric for the counter, which screws on the main shaft against the forward face of the cam, to which it is fastened by a screw.
225. In what position is a valve when air is admitted to the cylinder?	The curves of the cam for the valves are such that air is admitted over the valve to any cylinder, while its valve-rod roll is bearing against the curve nearest the center.
226. When is the valve in position of cut-off for expansion?	When the roll bears against the curve of intermediate distance from the center.
227. When is the valve open to exhaust?	When the roll is lifted by the curve farthest from the center.
228. At what part of the stroke is the cut-off?	At $\frac{1}{3}$ of the stroke.
229. What are the relief valves for?	For affording a relief for air or water cushioning on the outward stroke of the piston, while the port is closed by the main valve.
230. Where are the relief valves?	In the outer face of each main valve, the stem of which loosely fits in a socket in the end of the valve.
231. How are the relief valves ordinarily kept seated?	By the air pressure on their outer faces.
232. How are the valves removed from the valve chest?	Through a hole in the end of the valve chest and corresponding holes in the shell of the engine room. These holes are closed by screw plugs, screwed in against porpoise hide washers.
233. Of what is the engine room oil cup made and where is it secured?	It is made of bronze and is secured to the starboard lower side of the engine room to the cage by two holding screws.

WHITEHEAD TORPEDOES—Continued.

THE ENGINE—Continued.

Question.	Answer.
How is it filled?	Through a copper pipe, accessible from outside the shell, attached to its after end.
How is this pipe closed?	By a screw plug, against a porpoise hide washer.
How is the oil forced from the oil cup to the engine?	A small copper pipe connects the filling pipe, to which it is attached beneath the screw plug, with the outer end of the air passage of the starboard valve chest, another small copper pipe, for feeding the oil to the engine, connects the forward end of the oil cup with the socket in the crank case cover. The oil is forced from the oil cup through these pipes into the engine and valve chest.

THE VALVE GROUP.

What does the valve group consist of?	The reducing valve with its controlling valve, the regulator, the valve group oil cup, the starting lever, the friction cam, the friction roll and worm wheel, the bell crank, the balance lever, the distance gear sector with its adjusting spindle, the counter spindle and worm, and the counter ratchet.
For what purpose is the reducing valve?	It is for admitting air from the air flash to the engine, the pressure of air being governed by the position of the controlling valve within the reducing valve.
What is the function of the regulator?	It furnishes means for an adjustment by which the lift of the controlling valve and the corresponding opening of the reducing valve is proportioned to the pressure of air which it is desired to feed to the engine.
How is the push of the regulator transmitted to the controlling valve?	By the balance lever.
For what use is the valve group oil cup?	It contains a supply of oil for packing the stem of the controlling valve.
What is the action of the starting lever?	When the torpedo is launched from the tube, it automatically lifts the controlling valve, admitting air through the reducing valve. The motion of the starting lever is transmitted to the controlling valve, through the friction cam, the friction roll, the bell crank, and the balance lever.

WHITEHEAD TORPEDOES—Continued.

THE VALVE GROUP—Continued.

Question.	Answer.
243. What is the function of the distance gear sector?	It is set by the adjusting spindle and provi means for automatically closing the reduci valve and thus stopping the engine after torpedo has travelled a predetermined distar through the water.
244. What are the parts involved in this function?	The counter ratchet, the counter spindle a worm, the friction roll and worm wheel, the fr tion cam, the bell crank, and the balance lev
245. What is the reducing valve and what motion has it?	It is a piston valve, and has longitudinal verti motion in its chest, fitted at its lower end witl seat and closed at the top by a cover ground a tight in its seat, and held down by a follov screwed over it.
246. What works inside the reducing valve?	The controlling valve, which is also a piston val the stem of which slides air tight in a slee cast in the lower end of the casting.
247. Describe the passage of air through the reducing and controlling valve.	Air has constant admission to the annular spa between the two valve faces of the controlli valve; when the controlling valve is lifted, air admitted under the head of the reducing val lifting it from its seat, thus permitting air to p to the engine.
248. What lifts the controlling valve?	The upward push of one end of the balance lev and the downward push of the regulator spri against the other end of the balance lever.
249. What is the function of the regulator spring?	The more the regulator spring is compressed screwing down the regulator plug, the greater t push on the end of the balance lever agai which the regulator-spring barrel bears, and t greater the force exerted by the other end of t balance lever to lift the controlling valve; co sequently, the higher the lift of the reduci valve and the greater the pressure of air admitt to the engine.
250. Where is the balance lever pivoted?	On the end of the lower arm of the bell crank.
251. Where is the valve-group oil cup filled from?	Through an opening in the top accessible from ou side the shell of the torpedo.
252. How is the oil forced from the oil cup?	By air passing by an interior channel, drilled the body of the valve group, from below the se of the reducing valve to the bottom of the oil cu whence it is conveyed to the top of the cup l an axial air pipe forming a continuation of t interior channel. The pressure of air on top the oil forces it through a channel into a groo around the stem of the controlling valve.

WHITEHEAD TORPEDOES—Continued.

THE VALVE GROUP—Continued.

Question.	Answer.
53. How is the engine started?	By the starting lever on launching the torpedo.
54. Through what is its action transmitted to the controlling valve?	Friction cam, friction roll, the bell crank, and balance lever.
55. Where and how is the starting lever pivoted?	Its lower arm is pivoted in a socket cast in the valve-group body.
56. What carries the friction cam?	A pin eccentric to the pivot of the starting lever.
57. Where is the bell crank pivoted?	At the elbow on a pin cast in one with the body of the valve group.
58. Where is the friction roll carried?	On a pin on the upper arm of the bell crank at right angles from its inner face.
59. Describe the action of the starting lever.	When the torpedo is launched, the starting lever catches under a tripping latch in the tube and is thrown back. As it swings back it carries the friction cam to the rear against the friction roll, swings the upper arm of the bell crank aft, raises the lower arm of the bell crank and with it the balance lever, which is thus pressed up against the regulator-spring barrel and the stem of the controlling valve. The controlling valve is therefore lifted, and the reducing valve is consequently opened for the admission of air to the engine.
60. What does the distance gear govern?	It provides means for making the adjustment by which the range of the torpedo is determined.
61. Of what is the distance-gear sector made and where is it mounted?	It is a thin disk of brass mounted on an axle formed by a shoulder on the outer face of the starting lever, this shoulder being concentric with the pivot of the starting lever.
62. What is around the periphery of the distance-gear sector?	Teeth which engage with a worm on the lower end of the adjusting spindle.
63. How is the adjusting spindle supported?	In a sleeve cast in one with the body of the valve group.
64. What shape is its upper end and where is it accessible from?	Its upper end is squared and is accessible from the outside of the torpedo through a hole in the engine-room door.
65. How can the adjusting spindle be turned to give any desired position to the distance-gear sector?	By means of a socket wrench inserted through the hole in the engine-room door.

WHITEHEAD TORPEDOES—Continued.

THE VALVE GROUP—Continued.

QUESTION.	ANSWER.
266. What is the stud on the outer face of the distance-gear sector for?	The pin on the friction cam is brought against it by the return spring, when the adjustment for the range is made. The farther the distance-gear sector is turned from right to left, the farther will the friction cam be revolved about its axis by the return spring before the pin brings up against the stud, and the farther will the blank space in the rim of the friction cam be carried from the friction roll; consequently, the longer will be the run of the torpedo after it is launched before the blank space will arrive in the rotation of the friction cam, at such a position as will allow the friction roll to enter it.
267. How is a zero mark established?	By turning the distance-gear sector, carrying with it the friction cam through the contact of the pin with the stud, until the recess in the cam comes to the position where the friction roll is just ready to enter it, when the pointer on the engine-room door will point to zero mark on sector.
268. How is the distance gear set for a desired run?	First bring the zero on the sector in line with the pointer, then turn the adjusting spindle the number of turns to the left desired, each turn of the spindle being one tooth on the sector.
269. What care must be taken in making this adjustment?	That the pin on the friction cam is carried by the return spring against the stud on the sector.
270. Where is the data for this adjustment obtained?	From the record sheet issued with each torpedo.
271. Describe the action of the distance gear.	The counter spindle, to which is attached at its forward end the counter ratchet, is revolved by the engagement of the pawls, with the counter ratchet, the pawls receiving reciprocating motion from the eccentric for the counter on the main shaft. The worm on the after end of the counter spindle engages the worm wheel, mounted on a pivot on the inside face of the upper arm of the bell crank, and communicates motion of revolution to the worm wheel and to the friction roll, which is in one with the worm wheel. The friction cam is carried to the rear against the friction roll and is in firm contact with it, due to the pressure transmitted by the controlling valve and regulator spring through the balance lever and the bell crank. Consequently, as the friction roll revolves, it causes the friction cam to revolve also. The friction cam has a blank cut in its rim, and when this blank reaches the friction roll the latter is forced forward into it, the upper arm of the bell crank is no longer

WHITEHEAD TORPEDOES—Continued.

THE VALVE GROUP—Continued.

Question.	Answer.
	supported in its after position, and the lower arm of the bell crank, and with it the balance lever, no longer exerts a force tending to lift the the controlling valve. The latter therefore seats itself and the reducing valve closes, shutting off air from the engine.
272. What is the object of the retarding gear?	To retard the admission of air to the engine from the instant of launching until the torpedo reaches the water, thus preventing undue racing of the engine.
273. What does it consist of?	The retarding lever, the bell-crank lever, and the water tripper.
274. Where is the retarding lever pivoted?	To an eye on top of the crank case of the engine, in 3.55m mark I, and to an eye cast on the body of the valve group of latter marks.
275. What motion has it?	Fore-and-aft.
276. What does it carry on its lower end, and what is it for?	A lug, which, when the retarding lever is in its after position, projects over the forward end of the balance lever of the valve group at such a height as to allow the balance lever, when it is thrown up, to lift the controlling valve but a short distance, thus opening the reducing valve only slightly.
277. How is the upper end of the retarding lever shaped, and what fits in it?	It is forked, and in the fork slips a pin projecting from the side of the lower arm of the bell-crank lever.
278. Where is the bell-crank lever pivoted?	On the under side of the engine-room door.
279. What is riveted to its upper arm, which projects through a slot in the engine-room door?	Water tripper.
280. What is the water tripper made of, and its shape?	A thin plate of steel, shaped to conform with the curved surface of the engine-room door.
281. What is done to the water tripper before the torpedo is launched?	It is raised to a vertical position.
282. What takes place when the water tripper is raised in a vertical position?	It swings the lower arm of the bell-crank lever to the rear and moves the retarding lever aft.
283. When the torpedo enters the water, what happens to the water tripper?	The rush of water throws it down flat on the surface of the engine-room door.

WHITEHEAD TORPEDOES—Continued.

THE VALVE GROUP—Continued.

Question.	Answer.
284. What takes place when the water tripper is thrown down flat on the engine-room door?	It swings the lower arm of the bell-crank lever forward and moves the retarding lever forward, withdrawing its lug from over the end of the balance lever and, consequently, allowing the latter to give its full lift to the controlling valve, thus causing the reducing valve to open for the full pressure for which the regulator adjustment has been made.
285. How is the water tripper reretained in position, up or down, against light forces tending to displace it?	The pivot of the bell-crank lever, supported in the spring box, riveted to the under side of the engine-room door, is formed with an eccentric shoulder, filed flat on two sides, bearing on a spring barrel forced upward by a spiral compression spring within the box.
286. What is done with the water tripper in exercise, when using above and below water tubes.	It should always be raised when using tubes installed for over-water discharge, but never when using under-water tubes, as not only is there no occasion for retarding the admission of air in the latter case, but the velocity of injection may not be sufficient to cause the water tripper to be thrown down.
287. When is the sinking gear used, and for what purpose?	In action; and is for the purpose of automatically admitting water to the after body at the end of an unsuccessful run, thereby sinking the torpedo and removing it as a source of danger to friendly vessels, or preventing its falling into the hands of an enemy.
288. Where is the seat for the sinking valve?	In the engine bed plate.
289. Where does the stem on the after side of the sinking valve project?	In the after compartment of the after body.
290. How is the stem ground?	Water-tight.
291. How is it held firmly in its seat?	By a compression spring, encircling the stem between a nut on the after end of the stem and the after side of the sinking-valve seat.
292. To what, and how is the sinking valve connected?	It is pinned to the lower end of the sinking lever, which is movable in a fore-and-aft direction.
293. What is the fulcrum of the sinking lever?	A recess in the lower side of the sinking-lever block, which is supported by a clamp screw, accessible from the outside of the torpedo, passing through a clamp washer and a longitudinal slot in the engine-room door.
294. What is connected to the upper part of the sinking lever?	The sinking-lever hook.

WHITEHEAD TORPEDOES—Continued.

THE VALVE GROUP—Continued.

QUESTION.	ANSWER.
295. When is the sinking gear inoperative?	When the sinking-lever hook is disengaged from the pin projecting from the outer face of the upper arm of the bell crank of the valve group, and the sinking lever is set in its after position by clamping the sinking-lever block at the after end of the slot in the engine-room door.
296. What is done with the sinking lever and hook when the torpedo is fired for exercise?	It is taken out to prevent possible accidental sinking of the torpedo.
297. What else is done to cause the torpedo to sink besides hooking up sinking gear?	Remove one of the drain plugs in the after body.

THE STEERING ENGINE.

298. What is the use of the steering engine?	To manipulate the horizontal rudder to maintain the torpedo in a horizontal plane while it is running.
299. Where is it situated and how is it secured?	Situated on the port lower side of the engine room and is secured to the engine bed plate by two holding screws.
300. How is it operated?	By air, at the working pressure of the main engine, and transmits the action of the immersion mechanism with increased power to the rudder.
301. What is it made of?	Bronze.
302. What does it consist of?	The cylinder, the piston, the valve, and air-pipe connections.
303. Where does the steering engine receive air from?	From the port upper valve chest of the main engine.
304. Where is air from the steering engine exhausted?	Into the crank case.
305. Where is the steering engine valve connected?	To the lower connecting rod and sleeve of the system of levers of the immersion mechanism, by the valve rod, the union, and the locking jaws.
306. To what does the piston connect?	To the rudder, by the union, the steering rod, and a series of levers and connecting rods in the tail of the torpedo.
307. What does the piston and valve together constitute?	A following valve.

WHITEHEAD TORPEDOES—Continued.

THE STEERING ENGINE—Continued.

QUESTION.	ANSWER.
308. Describe the action of mechanism when the valve is moved forward?	When the valve is moved forward by the action of the immersion mechanism the valve faces uncover the channels and air passes to the after end of the piston, forcing it forward and putting the rudder up.
309. How is the piston packed in the cylinder?	By bronze spring packings surrounding ribs on the body of the piston. In the later marks the spring packing rings are omitted.
310. How is the cylinder head made air-tight?	It screws in against a porpoise-hide washer, and the stuffing box is packed with a thimble gasket of kid leather.
311. To what is the forward end of the valve secured?	It is screwed into the union, which is secured to the locking jaws of the immersion mechanism by a pointed screw.
312. What limits the travel of the valve in the piston?	The limiting plug.
313. What is rigidly attached to the valve rod?	The valve star, having six points.
314. What is the valve star for?	It is a means by which the valve can be adjusted.
315. To what and how does the forward end of valve rod connect to the union?	It screws into the union with a right-handed thread.
316. How can the valve rod be shortened?	By turning the valve star to the right, looking toward the head of the torpedo.
317. What is the zero or reference point of this adjustment?	It is that relative position of the valve within the cylinder which gives, when the valve is moved its full throw, a rudder movement of four divisions below the horizontal and three divisions above it, as indicated by a scale, divided in arc, on the port side of the after top blade of the tail of the torpedo.
318. How is accidental change of adjustment prevented?	By a set screw in the union.
319. What connects the piston with the steering rod?	The union.
320. What and where has it motion?	Longitudinal motion in a spring box formed by enlarging the forward end of the steering-rod tube.
321. To what does the after end of this union connect?	Forward end of the steering rod.

WHITEHEAD TORPEDOES—Continued.

THE STEERING ENGINE—Continued.

Question.	Answer.
22. What prevents the union from turning?	A guide stud in the spring box, which enters a longitudinal slot in the union.
23. What encircles the steering rod in the spring box?	A compression spring.
24. What is this spring for?	At the end of the run, when air is shut off from the steering engine, the spring forces the steering rod forward, thus putting the rudder up and bringing the torpedo quickly to the surface.

THE LOCKING GEAR.

25. What is the use of the locking gear?	To lock the steering-engine valve rod in a desired position until a sufficient time shall have elapsed to allow the pendulum to act independently of the inertia caused when the torpedo is launched.
26. What does the locking gear consist of?	The locking jaws, the locking lever, the locking-lever spring, the releasing lever, the releasing-lever spring, the ratchet bar, the ratchet-bar spring, the stop bar, the stop screw, and the locking star.
27. What does the locking jaws form?	The connection between the inner arm of the rock shaft of the immersion mechanism and the steering-engine valve rod.
28. Where and how does the locking and releasing lever pivot?	To studs in the after face of the bulkhead of the immersion chamber, the former at its middle point and the latter at its outer end.
29. To what does the ratchet bar pin, and what motion has it?	To the inner end of the releasing lever and has longitudinal motion in the vertical plane through the guide, secured by screws to the bulkhead.
30. To what does the stop bar pin?	To the inner end of the releasing lever, passing through a guide carried on the forward side of the inner end of the locking lever.
31. What has it at its lower end?	An eye.
32. What passes through it?	Stop screw.
33. Where is the stop-screw nut carried?	On the after side of the inner end of the locking lever, and has at either end a collar rigidly attached, one above the stop-screw nut and the other below the eye on the lower end of the stop bar.

WHITEHEAD TORPEDOES—Continued.

THE LOCKING GEAR—Continued.

Question.	Answer.
334. What has the stop screw at its lower end and for what purpose is it?	A square head on which can be shipped a socke wrench for the purpose of adjusting the sto screw higher or lower in the stop-screw nut whe making the adjustment for locking the steering engine valve rod.
335. How many teeth has the ratchet bar?	Thirteen saw teeth.
336. To what do they engage?	With teeth cut in the forward end of the counte spindle of the valve group.
337. How is the ratchet bar held against the counter spindle?	By the tension of the ratchet-bar spring.
338. How is the valve rod of the steering engine locked before a run?	The ratchet bar is pushed down by a stiff rod in serted through a hole in the top of the shell of th torpedo, forcing down the inner end of the releas ing lever and with it the stop bar against the ten sion of the releasing lever spring. As the stop ba descends the eye on its lower end bears agains the collar on the lower end of the stop screw, push ing it down, and consequently pulling down th inner end of the locking lever between the lock ing jaws, thus locking the steering-engine valv rod against the action of the immersion mechan ism.
339. How is the unlocking effected?	When the torpedo is launched and the engine is i motion the counter spindle is revolved by th engagement of the pawls with the counter ratche the pawls receiving reciprocating motion fro the eccentric for the counter on the main shaft c the engine. The revolutions of the counter spin dle permit the ratchet bar to be raised tooth b tooth until the smooth part of the ratchet ba arrives at the end of the counter spindle, whe there is no further restraint on the action of th releasing-lever spring, the releasing lever is pulle up and with it the stop bar, whose eye lifts th locking lever clear of the locking jaws, and th steering-engine valve rod comes under the con trol of the immersion mechanism.
340. How far will the torpedo run before it becomes unlocked when the ratchet bar is pushed down its full length?	About 100 yards.
341. How can the torpedo be locked for a shorter distance?	By pushing the ratchet bar down the require number of teeth and raising the stop bar b manipulating the stop screw.

WHITEHEAD TORPEDOES—Continued.

THE LOCKING GEAR—Continued.

Question.	Answer.
42. What is the purpose of the locking star?	It provides means by which the steering-engine valve rod may be locked in such a position as to maintain the rudder during the period of locking either horizontal or slightly up or slightly down.
43. What is the purpose of so locking the steering-engine valve rod?	So that the torpedo at the beginning of its run, before coming under control of the immersion mechanism, may neither make too deep a dive nor come so near the surface as to endanger broaching.
44. In which direction is the locking star turned for down rudder?	To the right, looking toward the head of the torpedo.
45. What is the zero or reference point of this adjustment?	It is a position of the locking lever in its fore and aft movement along its pivot which will cause the rudder to be locked in the horizontal plane.
46. What does a plus adjustment for the locking star indicate?	That the star is to be turned from the zero position the number of points directed to the right, locking the rudder down.

THE TAIL.

47. What portion of the torpedo is the tail?	The portion abaft the after body.
48. What parts does the tail comprise and what are they made of?	The gear box of bronze, the tail tube of bronze, and the frame of the tail of steel.
49. What does the latter consist of?	The forward and after-cone.
50. What do they each carry, firmly attached to flanges on its outer surface?	Two pairs of flat blades, one pair on each in the vertical plane passing through the axis of the torpedo, and one pair in the horizontal plane.
51. How are the blades designated?	The forward and after top blades, the forward and after-bottom-blades, and the forward and after-side blades.
52. How are the forward and after blades of each pair joined together?	They are joined stiffly together by rails.
53. What are they known as?	The top rail, bottom rail, and side rails.
54. What does the top rail carry at its upper edge and what use is made of it?	A guide which, entering the guide slot in the tube from which the torpedo is launched, insures accuracy of direction in launching.

WHITEHEAD TORPEDOES—Continued.

THE TAIL—Continued.

Question.	Answer.
355. Name the principal parts of the torpedo carried in the tail.	The bevel gears in the gear box by which the motion of the main shaft is transmitted to the outer tubular shaft in a contrary direction; the propellers, the rudder, the connections of the rudder with the steering rod, and the vertical vanes.
356. How is the gear box made and how is it secured?	It is in two parts. The forward half is riveted and soldered in the rear end of the after-body and the rear half, prolonged in a tube designated the tail tube, screws on the rear end of the forward half after the gears are in place, and is kept from turning by two keys inserted in corresponding slots in either side of the two halves.
357. What are the bevel gears made of and how many are there?	Made of bronze and are four in number.
358. How is the forward gear secured and held in place on the main shaft?	It is keyed on the main shaft and held in place by a nut secured on the main shaft abaft the gear.
359. How is the nut kept from turning after it is set up in place?	By a screw pinning it to the rear.
360. Into what do the intermediate gears engage and where are they carried?	The forward gear and are carried loosely on the crosshead.
361. Where are the after-gears and into what do they engage?	They are slipped on the main shaft abaft the intermediate gears and engage with them.
362. What are the intermediate gears carried on?	Sleeve bushing, slipped over the ends of the crosshead.
363. How are the bushings held in place?	By jam nuts, which are kept from turning by split pins.
364. What does the crosshead carry?	An axial sleeve, through which passes the main shaft.
365. What is in the top of this sleeve?	The gear box oil cup.
366. What does it consist of?	A bronze tube, accessible from outside the shell.
367. How many bearings in the tail of the torpedo has the main shaft?	Three.
368. Where are they?	One in the after end of the shaft tube and one at either end of the outer tubular shaft.

WHITEHEAD TORPEDOES—Continued.

THE TAIL—Continued.

Question.	Answer.
69. How many bearings has the outer shaft?	Two; one in each end of the tail tube.
70. Of what are the propellers made and how are they carried?	They are of steel, two bladed, with a pitch of 30 inches and of nearly equal blade area. They are carried in tandem, the forward propeller right-handed, on the outer tubular shaft, and the after, left-handed, on the main shaft.
71. Of what shape are the hubs and how are they secured to the propeller?	They are conical, and are bushed with bronze cones to each of which is secured its propeller with one key.
72. How are the cones secured to their respective shafts?	With two keys on opposite sides of the shaft.
73. Where are the propeller nuts?	They are screwed on the shafts abaft each propeller and force the propeller forward in place, causing the cones to bind the shaft firmly.
74. Where is the tail nut and what is it for?	It screws on the tail tube abaft the forward cone of the frame, holding the frame of the tail firmly in position.
75. How is the tail of the torpedo assembled?	The propellers, the propeller nuts, and tail nut are put in place in the frame of the tail and they are slipped together on the shafts. The tail nut and propeller nuts are then set up in succession until all parts are home, when each propeller nut is secured by a set screw.
76. In how many parts are the horizontal rudders?	In two parts, one on either side of the axial line of the torpedo.
77. Where are the outer ends pivoted?	In bearings secured by screws to the after ends of the side rails.
78. Where are the inner ends pivoted?	In the after cone of the tail.
79. What are the connections between the rudder and steering rod?	The steering bell crank, the forward connection, the balance connection, the after connection, and the tillers.
80. How are the connections made?	They are pinned snugly end to end, to transmit the movement of steering rod to the rudder easily, but without lost motion.
81. To what and where is the steering bell crank pivoted?	To the forward bottom blade, and is pivoted at its elbow.
82. To what and how is its upper arm secured?	To the steering rod, by a pointed screw.

WHITEHEAD TORPEDOES—Continued.

THE TAIL—Continued.

QUESTION.	ANSWER.
383. What connects to the tiller?	The upper end of the after connection.
384. What is on the port after side of the top blade?	A scale, graduated in arc, for use in connection witl the pointer, placed on the rudder when balancin the rudder.
385. What divisions has this scale?	Four above and 4 below the zero mark, the zer indicating the horizontal position of the rudder
386. How many degrees of arc do the 8 divisions embrace?	Fifteen degrees.
387. Where are the vertical vanes?	One on each forward side blade of the tail.
388. Where are they pivoted?	At their forward ends, and can be swung on thei pivots to starboard or port, to give a permanen rudder effect, for the purpose of correcting an deflection to right or left in the run of th torpedo.
389. In how many parts are the vertical vanes made?	Two parts, one above and one below the side blad of the tail.
390. From where is the sitting of the vertical vanes obtained?	From the adjustment sheet issued with each tor pedo.
391. What does a plus adjustment of the vertical vanes indicate?	That the starboard vane is to be set to the right, th number of divisions directed, the port vane re maining at zero.

THE DEPTH REGISTER.

392. What is the use of the depth register?	To automatically record the immersion of the tor pedo at all points of the run, furnishing data fo determining the efficiency of locking in checkin the initial dive and for adjusting the length o the steering engine valve rod to give a uniforn set depth during the run.

THE ROLLING REGISTER.

393. What is the use of the rolling register?	To automatically record the rolling of the torped to starboard or port during its run.
394. How is a permanent roll corrected?	By shifting the ballast or filling the tip of one of th blades of the propeller.

CHAPTER II.

MODIFICATIONS.

Question.	Answer.
5. What are the modifications of the 3.55 m., Mark I, to be found in the 3.55 m., Mark II?	The retarding lever, regulator spring, air-pipe jacket, buoyancy, valve group, stop valve, charging-valve seat, valve star, steering rod, and the mechanism for testing the hydrostatic piston.
6. What is the difference in the retarding lever?	It is pivoted between 2 arms, cast on the lower end of the cylinder which contains the controlling and reducing valves, and a small roller is fitted to the end of the bell crank of the water tripper, and is larger than the Mark I.
7. What is the difference in the regulator spring?	It is not completely relieved from compression until the plug is backed out 2½ turns above the zero position, but no account is taken of it, when making adjustments from the adjustment sheet.
8. What is the difference in the air pipe?	The air pipe is surrounded by a tubular water-tight jacket, extending from the after bulkhead of the immersion chamber forward for a distance of about 6 inches.
9. What is the difference in buoyancy?	The weight of the war head complete, including the war nose and primer, is 180 pounds, 10 ounces; that of the exercise head complete, including the exercise nose, is 177 pounds. With the air flask charged to 1,350 pounds and the torpedo completely ready for launching it weighs 840 pounds 10 ounces; in the exercise condition it weighs 837 pounds; in this condition it has an initial buoyancy of 1 pound.
0. What is the difference in the valve group?	The holding and air joint screws are of different sizes from those of the 3.55 m., Mark I.
1. What is the difference in the stop valve?	The operating spindle is made of steel. The lower section of the spindle below the collar is longer and the upper section is smaller than in the 3.55m., Mark I.
2. What is the difference in the charging-valve seat?	The seat is larger, requiring a larger washer, No. 8. A bouching is provided for the charging valve plug and seat.
3. What is the difference in the valve star?	It screws into the valve-rod union with a left-handed thread. The valve rod on which the star is mounted is longer than in the 3.55 m., Mark I.

MODIFICATIONS—Continued.

Question.	Answer.
404. What is the difference in the steering rod?	The length of the steering rod can be altered without taking off the tail. The steering-rod tube is larger.
405. What is the difference in the mechanism for testing the hydrostatic piston.	This can be done by turning the depth index to zero instead of using the bent lever as in the 3.55 m., Mark I. The nuts for the screws of the holding ring of the rubber diaphragm are of different size.
406. What are the modifications of the 3.55m., Mark II, to be found in the 3.55m., Mark III, and 5m., Mark I, torpedoes?	Dimensions, weights, etc., gyro-steering device, depth index, valve group, locking group, steering engine, tail joint.
407. What are the principal weights, dimensions, etc., of the 3.55m., Mark III, and 5m., Mark I.	The principal dimensions of the 3.55m., Mark III, and 5m., Mark I, torpedoes are:

	3.55m., Mark III.	5m., Mark I.
Extreme length { feet	11	16
Extreme length { inches ..	9.6	6.8
Greatest diameter.. ......do..	17.7	17.7
Capacity of air flask...... ....cubic feet ..	7.15	9.9
Weight of air charge, 62° F., at a compression of 1,350 pounds per square inch ....pounds..	50	69.2
Weight of gun-cotton charge in war head, dry 94.8 pounds and 176 pounds, respectively, plus 25 per cent water (approximately) ......pounds..	118½	220
Displacement of torpedo in sea water, sp. gr. 1.026, at 62° F. (approximately ....pounds..	838	....
Weight of torpedo with air flask charged to 1,350 pounds per square inch and war head attached, ready for launching (approximately)...........pounds..	845	1,161
Weight of same in sea water (approximately) .. pounds..	[a] 7	....
Reserve buoyancy of same in sea water with pressure in air flask reduced to 1,050 pounds per square inch (approximately)...pounds..	4	21

[a] The torpedoes of this mark that are fitted with the gyro gear have about 21 pounds negative buoyancy when fully charged and ready for launching.

MODIFICATIONS—Continued.

Question.	Answer.	3.55m., Mark III.	5m., Mark I.
	Weight of torpedo with air flask charged to 1,350 pounds per square inch and exercise head attached, ballasted with fresh water (approximately) . . pounds . .	836	1, 161
	Reserve buoyancy of same in sea water (approximately) . . . . pounds . .	2	6
	(Owing to variations in weights of air flasks and tail sections, there may be no reserve buoyancy.)		
8. What is the difference in the steering device?	The 3.55m., Mark III, except about 20 of the earliest ones, and the 5m., Mark I, torpedoes are fitted with gyro steering gears.		
9. What is the difference in the depth index?	The depth index is carried in a body, screwed and riveted to the shell of the torpedo, forward of and close to the joint ring of the immersion chamber, and consists of a bevel worm wheel, having a narrow cylinder face on which the figures 5, 10, 15, and 20 are stamped for making the adjustments for the depth.		
0. What is the difference in the valve group?	The valve group differs from that in previous marks by carrying an engaging rod, or shifting bar, whose office is to draw the upper (toothed) end of the rack (replaces old ratchet bar), into engagement with the teeth of the counter spindle.		
1. What is the difference in the locking gear?	The locking gear of these marks differs in constructing entirely from those of the previous marks, and is known as the locking-gear group.		
2. What are the principal parts of this group?	The rack, cylinder of the steering engine, bolt and arm constituting the main bearing, outer bevel gear sector, inner bevel-gear sector, locking bar, lock sleeve, locking adjustment index, and the valve-adjusting screw.		
3. How is the valve rod connected with the rock shaft?	By a square-headed pointed screw.		
4. How is the valve rod lengthened or shortened?	By the adjustable union and adjusting screw.		
5. Which way is the screw turned to lengthen the rod?	Right.		

MODIFICATIONS—Continued.

Question.	Answer.
416. How is the steering engine locked?	By turning the locking adjustment index to the left the desired number of graduations and clamp it, and then with the locking key turn the outer bevel-gear sector to the left until the key brings up against the index.
417. How is the rudder locked up?	Turn the cam sleeve to the left the desired number of divisions.
418. When is the rudder horizontal?	When the zero mark of the adjustment cam sleeve is in coincidence with the reference mark on the index washer.
419. What is the difference in the steering engine?	In these marks the piston has but three ribs, without packing rings.
420. What is the difference in the tail joint?	The forward cone of the tail is flanged inwardly to make a substantial joint ring that fits over and against a corresponding joint surface worked on the rear face of the after-body joint ring, 8 screws uniformly spaced, secure the 2 parts together. The propeller shaft, in 2 sections, is coupled in the wake of the tail joint, the after section fits as a sleeve over the forward one, and is held by 4 feathers and slots, the forward gear of the bevels is forged in one with the after section of the shaft
421. What is done with the screw that connects gyro-steering rod to vertical rudders when gyro gear is not used?	It is entered in the locking hole of the tail cone to lock the rudder yoke, and thus holding the vertical rudders amidships.
422. What are the modifications of the 5m., Mark I, to be found in the 5m., Mark II?	The war and exercise heads, air flask, depth index engine, reducing valve, valve group, locking gear, sinking gear, tail joint, fittings for submerged discharge and gyro-gear reducing valve
423. What are the dimensions and weight of the 5m., Mark II, torpedo?	Extreme length, 16 feet 6.8 inches (over war nose). Greatest diameter, 17.7 inches. Capacity of air flask, 11.77 cubic feet. Weight of air charge, 62° F., at a compression o[f] 1,500 pounds per square inch, 91.4 pounds. Weight of charge in war head, 105.6 pounds dr[y] gun cotton plus 25 per cent water (approximately), 132 pounds. Displacement of torpedo in sea water, specifi[c] gravity 1.026 at 62° F. (approximately), 1,23[?] pounds. Weight of torpedo with air flask charged to 1,50[0] pounds per square inch, and war head attached ready for launching, without under-water attachments (approximately), 1,230 pounds. Reserve buoyancy of same in sea water (approximately), 2 pounds. Reserve buoyancy of same in sea water with pressure in air flask reduced to 1,050 pounds per square inch (approximately), 29 pounds.

MODIFICATIONS—Continued.

Question.	Answer.
	Weight of torpedo with air flask charged to 1,500 pounds per square inch and exercise head attached, ballasted with fresh water (approximately), same as with war head. Reserve buoyancy of same in sea water (approximately), same as with war head. Weight of under-water attachments, 11 pounds. Weight of torpedo without air or under-water attachments, 1,139 pounds. Owing to variations in weights of air flasks and tail sections, etc., the buoyancies given above may vary somewhat.
24. What is the difference in the heads?	The heads are blunt, are ballasted with lead weights, buoyancy chambers are put in to give stability, the exercise head can be filled from outside the shell, through a filling plug, and are joined to the air flask by 22 joint screws. The exploder will act if the blunt-nose torpedo strikes with its axis less than 58° from the normal to the attacked surface, while with the sharp-nose torpedo, it will act if the angle is within 70°.
25. What is the difference in the air flask?	It is longer and heavier, and has a working pressure of 1,500 pounds to the square inch. It is fitted with heavy top and bottom guides for submerged discharge, and the forward head is removable.
26. What is the difference in the depth index?	The only modification in the depth index is that the shoulder carrying the worm is in one with the spindle, and the thread is of coarser pitch.
27. What are the differences in the engine?	The engine body carries the reducing-valve chest cast on the lower front face of the vertical valve chest. On the 2 sides of this vertical valve chest, on the 2 lower sides of the crank case, and on the lower sides of the other 2 valves, chests are cast in one with the engine body, the air passages supplying air to the main engine and also to the steering engine, the gyro steering gear, and the engine-room oil cup. These air channels connect with the air space in the reducing-valve chest beneath the reducing valve. The lower end of the vertical chest connects directly with this space. The crank case cover seats on a valve seat in the crank case and is secured by a screw-follower lock ring. The cover is held in position by a locating pin fitting into a corresponding hole in the valve-ring guide, and the lock ring is kept from turning by the locking strip. Cast on the forward face of the cover is a socket casing, which carries the forward bearing and takes the thrust of the main shaft, and in one with this casing is the casing for the worm wheel on the lower end of the intermediate counter spindle. This worm wheel, which is accessible

MODIFICATIONS—Continued.

Question.	Answer.
	through a hole in the bottom of the casing, closed by a screw plug, is operated by the worm on the forward end of the main shaft. On top of this casing is an inverted slot-guide bearing which carries the reducing-valve spring rod. There is also a nipple on this casing on which is soldered the oil pipe, supplying oil to the shaft from the engine oil cup. Cast in one with the valve-ring guide is a spider frame, carrying a bushed bearing for the main shaft just forward of the crank. The guides for the valve rolls are no longer completely circular nor furnished with grooves for tongues on the rolls, but the front segments of the circular guides are cut away and the rear face of the crank-case cover screwing up flat against the forward face of the valve guide prevents the valve rolls from turning. Instead of an eccentric for the counter, a concentric screw-follower ring holds the cam for the valves in place. The counter spindle, operating the distance and locking gear, receives its rotation from the main shaft through the intermediate counter spindle. A worm on the forward end of the shaft operates the worm wheel on the lower end of the intermediate spindle, located in the casing on the crank-case cover. A worm on the upper end of this spindle operates the wheel on the forward end of the counter spindle. The piston of the main engine is about $\frac{1}{8}$ inch greater diameter. It has only 1 recess for packing rings and is packed with 2 rings, one on top of the other. Two short pillars are cast on the engine body to receive the holding-down screws of the valve group.
428. What is the difference in the reducing valve?	The chest of the reducing valve is cast in one with the body of the main engine. It is situated on the lower front face of the vertical valve chest and is cylindrical in shape, the lower end being closed by a screw plug against a porpoise-hide washer, the upper end being opened. The principal parts of the reducing valve are as follows: The valve chest; the valve body, consisting of the valve, stem, and plunger; the valve spring; the valve-spring rod; the valve adjusting sleeve nut, and the valve lever. The valve stem and plunger are in one. The valve lever, in shape of a reversed interrogation point, has its lower end rounded and fits loosely in the socket in the top of the reducing-valve plunger; its upper end is flattened out into a ring which fits, by means of a flange sleeve, or collar, over the valve-stem rod. The valve-spring rod, a round vertical rod, has its lower end flattened and shaped into a head to fit into the inverted T slot on the upper side of

MODIFICATIONS—Continued.

Question.	Answer.
	the box cast on the crank-case cover, and in which works the forward end of the shaft. The upper end of the rod is screw threaded, and on it screws, up or down, the adjusting sleeve nut. The valve spring, a stout spiral spring, fits loosely over the spring rod and rests on a flange of the sleeve in the upper end of the valve lever. The adjusting sleeve nut is a long, hollow, cylindrical nut, screw threaded on the lower portion of the inside to work on the spring rod. The lower end of nut is broadened out into a flange that bears against the upper end of the valve spring. The operation is as follows: Screwing down on the adjusting nut compresses the valve spring, which rests on the flange of the sleeve of the lever, thus forcing the lever down, which in turn bears against the socket in the plunger of the reducing valve and forces the valve from its seat, acting against the air pressure on the bottom face of the plunger. Air, which has free access from the main valve through the air pipe to the reducing-valve chest, between the plunger and the valve face, now passes by the reducing valve to the space in the valve chest below the valve seat, and thence, by the air channels, to the main valve chests, and thence to the cylinders. The number of turns to be given to the adjusting nut, and consequently the amount of compression given to the spring, is determined by the distance which the torpedo is to run, and it is to be taken from the adjustment sheet furnished with each torpedo. The zero, or reference point, of this adjustment is that position of the adjusting nut which allows its lower face just to bear on the upper end of the valve spring without compressing it. The compression of the valve spring causes the reducing valve to open more or less, according as the flask pressure exerted on the lower face of the plunger is less or greater. The reducing-valve oil cup is in the forward end of the engine room on the right-hand lower side. It is filled from the outside and is closed by a screw plug against a porpoise-hide washer. A small air channel, drilled vertically in the chest of the reducing valve, leads from the air space underneath the plunger to one of the small nipple connections on the outer face. Thence air passes by means of the small air pipe to the top of the oil cup and forces oil through the small pipe leading from the bottom of the oil cup to the other small nipple connection into the annular groove around the inner face of the valve chest, and thus oils and packs the plunger, and the oil passes, by means of the small vertical groove in the face of the plunger, into the air that goes to the engine.

MODIFICATIONS—Continued.

Question.	Answer.
429. What is the difference in the valve group?	Two vertical hollow cylinders, cast in one with bearing for the starting lever between them form the body of the valve group. On the base of the forward cylinder are lugs for th holding-down screws and for bearings for th counter and intermediate counter spindles; o the body are 2 nipples for connections for ai pipes, one from the air flask, the other to th reducing valve, and a stud bearing for the bel crank; on the top are 2 lugs for bearings for th toggle connection and a boss to serve as a sto for the starting lever when down. The principal parts composing the valve grou are as follows: The main valve cylinder, the dis tance gear cylinder, or regulator-spring barrel the starting lever, the bell crank or lever for th pinion sleeve, the starting link, the balanc lever, the counter spindle, the pinion sleeve the intermediate counter spindle, the distance gear worm wheel, the friction wheel, the wate tripper, the retarding lever, the toggle connec tion, the connecting rod and sleeve, and the ai connections. The main and starting valves are raised by th balance lever, which is operated by the startin lever and the regulator spring, inside the regu lator-spring barrel. The water tripper actuates the retarding gear which, in turn, prevents or allows the full actio of the balance lever on the stem of the mai valve. The distance gear, consisting of the distance-gea worm wheel and friction wheel, is actuated b the counter and intermediate counter spindle.
430. Describe the main and controlling valves.	The main valve cylinder carries on its inner face about halfway up, the seat for the valve. O the inner face of the bottom is cast a stuffing bo serving at the same time as a guide for the valv stem. This stuffing box is packed by a kid leather washer and a screw-follower ring. Th top of the cylinder is closed by a valve plug which is kept seated air-tight by a screw-follow plug. The main valve is a cylindrical plug that work air-tight, face downward, in the valve cylinde Around its exterior surface, above the valve sea is a large annular space cut out, which is in dire connection, through an air pipe, with the a flask. In the upper end of the main valve is cylindrical recess, which forms a seat for th starting valve, and also for the lower end of small spiral spring, the upper end of which bea against the inner face of the valve plug. Throug an axial hole in the main valve passes the ste of the starting valve. A small passage is drille

MODIFICATIONS—Continued.

Question.	Answer.
	through the main valve connecting the annular space around the valve with a recess in the upper end, and two small passages are drilled from the lower face, connecting the space below the valve seat with the axial hole. The main valve stem, of larger cross section than the axial hole in the valve, is separate from the valve and works up and down, air-tight, through the stuffing box in the bottom of the cylinder. When the valve stem is raised by the balance lever its first function is to bring up against the stem of the starting valve and lift that valve slightly. The starting valve and stem are in one piece. On the head of the valve is a small nipple that fits into the hollow recess of a round cap that forms a bearing surface for the lower end of the spiral spring. The cross section of the valve stem is triangular, except at the lower end, where it projects through the axial hole in the main valve, which is cylindrical. There are thus formed spaces between the valve stem and the wall of the axial hole for the air to pass into when the starting valve is raised.
Describe the starting gear.	The starting lever is a bent lever, whose upper arm projects through a slot in the engine-room door and whose lower arm pivots in a bearing cast in the valve group body. On the pivot face is an eccentric pin that carries the upper end of the starting link; the lower end of this link pivots in a slot in the balance lever. On the lower arm of the starting lever; from the face opposite the pivot, projecting at right angles, is a pin eccentric to the pivot, on which rests the upper arm of the bell crank. This pin also works in a double-curvature vertical slot in the link that connects with the push rod that acts on the releasing spring of the gyro gear. The link moves aft with the starting lever, and through the push rod releases the spring that actuates the gyroscope. The balance lever hangs by a pin bearing from the lower end of the starting link. The forward end of the lever pivots to the lower end of the connecting-rod sleeve; the after end widens into a yoke and carries on each lug of the yoke, by a short axle-pin bearing, a cone-shaped friction roll that bears against the lower rim of the friction wheel when the distance gear is in action. A fulcrum bracket hanging beneath the main valve cylinder embraces the balance lever under 2 studs on the forward arm. At the end of a run, when the starting lever is thrown forward, the balance lever pivots on this bracket and the friction rolls are thrown clear of the slots in the friction wheel, leaving the wheel free to be turned by the return spring.

MODIFICATIONS—Continued.

Question.	Answer.
432. Describe the retarding gear.	The water tripper is a bell-crank lever whose upp end projects through a slot in the engine-roo door and is formed into a thin blade, at rig angles to the slot, made to conform to the curve surface of the door when lying flat. It pivo on a screw pivot to the side of the distance-ge cylinder, and to the lower arm is pivoted the r tarding lever. A longitudinal hole, drilled i the upper arm, carries a small spiral sprin which is in compression and bears upon the fl face of the screw pivot when the water tripp is up. This serves to keep the tripper up, b is not strong enough to resist the action to thro it down when the torpedo enters the water. The retarding lever joins the lower arm of t water tripper to the upper end of the connec ing rod by means of the toggle connection, whi pivots between the 2 lugs on the upper e of the main valve cylinder. The connecti rod works in a sleeve whose lower end pivo to the forward end of the balance lever. T amount of entry of the rod into the sleeve controlled by the adjusting nut. The object this gear is to retard the admission of air to t engine after the starting lever is thrown ba until the torpedo enters the water.
433. Describe the distance gear.	The distance-gear cylinder is open at both en Into the bottom screws a follower plug with central hole through which passes a sho hollow spindle of the distance-gear worm whe On the inner end of this spindle screws a flang collar that bears on a shoulder on the follow plug and supports the distance-gear worm whe The upper end of this cylinder is closed fr the inside by the distance-index washer, round, flat disk, with a central hole throu which passes the spindle of the friction wh and whose outer edge is beveled to form a s against a corresponding flare in the inner wa of the cylinder around its upper edge. T washer is held in its seat by a stout spiral co pression spring, whose lower end rests on collar on the spindle of the distance-gear wo wheel. The right semicircle of the upper f of the cylinder, at its outer edge, is gradua for every 400 yards up to and including 1, yards. Two pin stops in the fore-and-aft l on this outer edge and a pin stop on the up face of the distance-index washer control movements of the pointer in the right semicir The pointer fits over a square section of friction-wheel spindle and moves with it. T spindle has free movement in the index wash Closely surrounding this spindle, inside regulator spring, and passing through the holl spindle of the distance-gear worm wheel i

MODIFICATIONS—Continued.

Question.	Answer.
	small spiral spring (the return spring), the upper end of which is rigidly attached to the distance-index washer and the lower end to the friction wheel. The distance-gear worm wheel is a flat circular disk with a short, hollow spindle from its upper face, the upper end of the spindle being supported in the distance-gear cylinder as explained above. The wheel is free to revolve in the cylinder and has a slight freedom of vertical motion against the regulator spring. The outer rim of the wheel is broadened into a flange, and teeth are cut around its circumference in which works the worm on the after end of the counter spindle. The inner lower edge of this flange is beveled and forms a friction bearing for the friction wheel. The friction wheel is a flat circular disk with its edge turned down, making an inverted shallow cup. In the rim of this cup, diametrically opposite each other, are cut 2 slots into which the friction rolls will fall, when, by the revolution of the disk, these slots are brought over the rolls. The lower edge of this rim is beveled from the outside and against this bevel bear the cone-shaped friction rolls. The upper edge of this rim is also beveled from the outside, and when the starting lever is thrown back it bears against the beveled edge in the rim of the distance-gear worm wheel until the slots are brought over the rolls. Rigidly attached to the wheel at its center is a spindle, the upper portion of which passes through the distance-gear cylinder and the index washer where it is held in place by the index pointer pinned to its upper end. The lower portion of the spindle extends between and just below the axle bearings of the friction rolls and terminates in a flat round head. On this lower portion works a split collar carrying bearings for the inner ends of the axles of the friction rolls. The counter spindle, is a round horizontal shaft, resting in two lug bearings cast in the valve group body. The after end terminates in a flat circular worm disk that actuates the distance-gear worm wheel, the forward end is of square section and on this fits the worm wheel that is actuated by the intermediate counter spindle. A pinion sleeve, and spiral spring for operating the locking gear are carried on the counter spindle. The intermediate counter spindle is a round vertical shaft. The upper end is supported in a lug bearing cast in the valve group body and carries a worm disk that actuates the worm wheel on the forward end of the counter spindle. The lower end rests in a casting cast on the crank case cover and carries a worm wheel that is actuated by a worm on the forward end of the shaft of the engine.

MODIFICATIONS—Continued.

Question.	Answer.
434. What is the difference in the locking gear?	The only difference in the locking gear of th 5m., Mark II, torpedo from that of the 5m. Mark I, is the valve group modifications for en gaging and disengaging the rack, and that screw instead of a nut is used to lock the ad justment cam sleeve. A spiral spring and th pinion sleeve fit over the shaft of the counte spindle. The after end of the spring bears on washer against the after lug bearing of the counte spindle; the forward end bears against the rea face of a shoulder on the after end of the pinio sleeve. Near the forward end of the sleeve is collar which forms a bearing surface for th counter spindle in the forward lug bearing, an around the circumference of which teeth are cu to engage the teeth of the rack. Forward of th collar for the rest of its length, the sleeve return to its normal diameter and its surface is smootl It is on this blank space the rack must re when setting the locking dial, and which it wi always do when the starting lever is throw forward. The inner surface of the sleeve is cylindrical ex cept at its forward end where there is a squa shoulder that fits over the square section of th shaft of the counter spindle, thus permitting th sleeve to have longitudinal motion along th shaft but compelling it to rotate with the shaf A circular recess in the shoulder on the after fac of the counter-spindle worm wheel is cut ou to receive the blank space on the pinion sleev when this is shoved forward by the spiral sprin to engage the teeth of the rack. The bell crank pivots on a stud cast on the side the main valve cylinder. Also on this stu pivot, by means of a horizontal slot, works th connecting link to the push rod that operat the releasing spring of the gyro gear. The u per arm of the lever rests on the eccentric piv on the front face of the starting lever and mov down or up according as the starting lever thrown back or forward. The end of the low arm rests against the front face of the should on the after end of the pinion sleeve and mov back or forward according as the upper ar moves up or down, thus withdrawing the pinic sleeve from engagement with the rack or pe mitting the compressed spiral spring to shove forward into engagement. A horizontal pin in the forward lug bearing pr vents the rack from being lifted out of the spac between the lug bearing and the flange on th shoulder of the worm wheel. and so forces into engagement when the pinion sleeve thrust forward.

MODIFICATIONS—Continued.

Question.	Answer.
35. Describe the operation of the valve group.	When the distance index pointer is at zero the slots on the friction wheel, are vertically over the friction rolls. Upon turning the index washer to the right, the friction wheel and spindle being free to move, are turned by a small spiral spring until the pointer indicates the number of yards desired for the run. This brings the slots in the friction wheel at the desired distance from the friction rolls. Upon opening the stop valve air from the flask enters the main valve cylinder above the valve seat, into the annular space around the valve and thence through the air passage, to the recess in the base of the valve, where the starting valve seats. Upon raising the water tripper the retarding lever is drawn back and the toggle connection, bringing with it the connecting rod and sleeve, is drawn vertically underneath its upper pivot, thus forming a rigid connection between the forward end of the balance lever and the lug cast on the upper end of the main valve cylinder, except for the slight play allowed by the adjusting nuts. As the torpedo, upon being fired, starts to leave the tube, the tripping latch catches under and throws back the starting lever. Through the starting link this raises the balance lever, which pivots at its forward end and the after end is raised, bringing the friction rolls up against their bearing surface on the lower edge of the friction wheel. The bearing surface on the upper edge of the friction wheel is thus brought to bear closely against the bearing surface in the lower inner flange of the distance gear worm wheel and the whole is pushed up into the distance gear cylinder against the regulator spring, compressing it still further. At the same time a small lug raised on the forward arm of the balance lever brings up against the lower end of the main valve stem, the upper end of which bears against the stem of the starting valve, which projects slightly below the main valve. This lifts the starting valve slightly, against the pressure of the spiral spring and of the air above it, and permits the air to enter into the space in the axial hole between its walls and the faces of the starting-valve stem. Hence the air passes through the passages into the space below the main valve and thence through the lower air-pipe connection to the reducing valve, whence it passes to the engine, starting and running it slowly. When the torpedo enters the water the water tripper is thrown down. This through the retarding lever and toggle connection draws the connecting rod and sleeve from their vertical position and frees the forward end of the balance lever.

MODIFICATIONS—Continued.

Question.	Answer.
	The lever now pivots on the lower end of the starting link, the after end is forced down by the regulator spring acting through the distance-gear worm wheel, friction wheel and friction rolls, and the forward arm is forced up, lifting the main valve from its seat and permitting air at flask pressure to pass on to the reducing valve. In the meantime the counter spindle, which is operated through the intermediate counter spindle by the main shaft, actuates, through its worm wheel, the distance-gear worm wheel, turning it in a direction contrary to the hand of a watch. This in turn, because of the friction between their surfaces, carries with it, against the tension of a small spiral return spring surrounding the spindle, the friction wheel bearing on the friction roll, until the slots in the wheel come vertically over the rolls. This will be at the end of the run when the index pointer is brought back to zero. The after end of the balance lever being now free to move up, the forward end yields to the pressure exerted by the compressed spiral spring and the air on top of the main valve, which pressure seats the main and starting valves and cuts off air from the engine.
436. Describe the sinking valve.	In the upper right-hand quadrant of the engine bedplate is a circular hole in which fits, air and water tight, from the after side of the plate a spider frame, carrying the valve seat for the sinking valve. The valve seats with its face aft and opens into the engine room. The valve stem works in a circular guide formed by the yokes of the spider frame. A spiral spring fits over the valve stem and rests on the bearing surface formed by the after face of the valve-stem guide. The after end of the stem is screw threaded, and a nut screwing on it against the spring compresses the spring and holds the valve in its seat. The valve stem, extended, continues forward into the engine room until its end comes abreast the friction rolls. This end is formed into a square head through which is a vertical hole, screw threaded. Into this hole can be screwed a vertical rod, the sinking lever, from outside the shell of the torpedo. The object of the sinking valve is to sink the torpedo at the end of an unsuccessful war shot, and its operation is as follows: Screw the sinking lever, through the hole in the shell of the torpedo, into the forward end of the sinking-valve stem. This sinking lever will be just clear of the friction wheel. On the right semicircumference of the friction wheel, and partly overlapping the slot for the friction roll, is a boss or lug. At the end of the run, just before the friction rolls can fall into their slots, this boss brings up against

MODIFICATIONS—Continued.

Question.	Answer.
	the sinking lever and, the friction wheel continuing to revolve, the sinking valve is drawn forward against the compression of the valve spring and water is admitted to the after body of the torpedo, sinking it. For exercise this sinking lever is left out. In this case the boss on the friction wheel passes freely over the horizontal valve stem and the valve is not disturbed from its seat.
What are the differences in the tail joint?	The tail is heavier and stronger. The number of teeth in the gears is reduced from 30 to 24 and the pitch-line diameter is slightly increased. The top and bottom rails are fitted with guides for submerged discharge. The tail is what is known as the Fuime tail, the propellers being four bladed.
What are the fittings for submerged discharge?	Extra guide studs are fitted, 2 on the air flask, top and bottom, 2 on the sides over the junction of the after body and the immersion chamber, and 1 each on the top and bottom rails of the tail. These are removed for above-water discharge and the screw holes filled with albany grease. The heads are joined with 22 screws instead of 12, the after body with 24 instead of 18, and the tail with 12 instead of 8, as in previous marks. The gyro-gear door is heavier, is of bronze, and is secured air and water tight by only two holding screws.

CHAPTER III.

THE GYRO MECHANISM.

Question.	Answer.
439. What does the gyro steering device consist of?	It consists essentially of the gyroscope (wheel ar two gimble rings); the impulse sector, the ir pulse spring, the cam shaft, the air-cushion cyli der, the valve mechanism, the steering engir and the frame.
440. What are the minor parts?	The horizontal rock shaft, the position holder, t vertical rock shaft, the centering stud, and t rock-shaft spring.
441. What does the relative movement between the axes of the torpedo and the gyroscope wheel when running operate?	The relative movement operates the valve of tl steering engine, giving motion to a steering rod.
442. What does the steering rod operate by suitable mechanism?	It operates a pair of vertical rudders by which tl horizontal direction errors of the torpedo are co trolled.

THE GYROSCOPE.

443. What is the gyro wheel made of?	Tobin bronze, and of compact pattern.
444. Where is it enlarged, and why?	Near its periphery for proper distribution of mass.
445. What is its diameter and weight?	Its diameter is $3\frac{1}{8}$ inches and weight $1\frac{3}{4}$ pounds.
446. How long is its axle?	It is $2\frac{7}{8}$ inches long and tapers toward its extren ties.
447. What are inserted in the ends of the axle, and why?	Hard steel bearings, coned to receive the pivo upon which the wheel turns.
448. What is near one extremity of the axle?	It is toothed to correspond with the teeth of the ir pulse sector by which it is actuated.
449. How is the wheel made?	Drop forged and finished in the lathe, centered its steel bearings.

THE GYRO MECHANISM—Continued.

THE GYROSCOPE—Continued.

Question.	Answer.
50. How and of what is the inner ring made?	Made of Tobin bronze, drop forged and carefully machine finished.
51. At the extremities of one diameter of the ring what are inserted, and what turns upon them?	Cone-shaped steel pivots are inserted, upon which the wheel turns.
52. How are the pivots secured to the ring, and why?	By the threaded portion, and thereby are adjustable to the bearings of the wheel.
53. Why is the ring split through the holes tapped for the pivots?	So that the pivots may be securely fixed after adjustment, by set screws, binding the split portions together.
54. What are fitted at points on the outer surface of the ring, 90° from the pivots?	Steel bearings, by which it is supported and may revolve upon the pivots of the outer ring.
55. Why is a portion of the inner ring slotted away?	To avoid interference with the impulse sector, in its engagement with the toothed axle of the wheel.
56. Why is the outer end of the pivot that carries the toothed end of the axle coned out?	To afford entrance of the centering stud, by which the wheel is held true during the application of impulse by the sector.
57. How is the outer ring fitted?	With pivots and bearings.
58. What are the pivots adapted to?	The bearings of the inner ring, and are adjustable.
59. What do the bearings of the outer ring permit?	The gyroscope as a whole to revolve about a vertical axis, pivots being adjustable and secured in a frame by the clamp screw.
60. What secures to the outer ring in a vertical position?	The control pin, by which the valve arm is actuated, admitting air to the steering engine.

THE IMPULSE SECTOR.

61. What does the impulse sector consist of?	Of a substantial shaft 3 inches long and $1\frac{1}{8}$ inches external diameter. From its upper extremity a broad cone-shaped flange spreads outward and downward, upon the lower edge of which teeth are cut for the engagement with the axle of the gyroscope wheel. The radius of the sector is $2\frac{3}{16}$ inches, and it comprises 276° of arc. The remaining portion is entirely cut away.

THE GYRO MECHANISM—Continued.

THE IMPULSE SECTOR—Continued.

Question.	Answer.
462. Why is it cut away?	For the free operation of the gyroscope without interference after the impulse has been given.
463. What is the boss and its use?	It is a small projection on the impulse sector which, by its operation on the boss arm of the vertical rock shaft, withdraws the centering stud from the gyroscope wheel immediately after the impulse is given.
464. What is the stop and its use?	It is a small thick steel plate screwed to the upper surface of the sector; it limits in both directions the rotation of the impulse sector upon its axis.
465. What is the stop arm and its action?	It is a steel link, having an eye at one end by which it turns freely around the upper extremity of the cam shaft; the outer end is fitted to work in a slot of the air-cushion piston. By rotation of the impulse sector about its axis the stop finally bears against and moves the stop arm, which in turn drives the piston toward one end or the other of the air cushion cylinder, according to the direction of the rotation.
466. What is the cam shaft?	It is a stiff bronze rod inserted axially in the hollow shaft of the impulse sector.
467. How are its ends fitted?	It has a cam at its lower end and a square section near its upper end, fitting a corresponding orifice in the top of the sector.
468. What does the socket in the cam end permit?	The insertion of the winding key, by which the necessary tension is given to the spring and the sector turned into position for giving the impulse.

THE IMPULSE SPRING.

Question.	Answer.
469. What is the impulse spring?	It is a helicoid of 18 turns of No. 8 wire (B. W. G.) wound on a cylinder $1\frac{3}{16}$ inches diameter and 3 inches long. The ends of the wire are hooked outward to embrace the driving studs, one of which is in the bottom of the frame and the other in the impulse sector.
470. Describe the action of the impulse spring.	When the cam is released by tripping the cocking toe the torsional effort of the spring on the stud causes the impulse sector to revolve upon its axis until arrested by the stop arm, and to transmit rapid rotation to the wheel of the gyroscope.

THE GYRO MECHANISM—Continued.

THE AIR-CUSHION CYLINDER.

Question.	Answer.
471. Describe the air-cushion cylinder.	The body of this cylinder is a continuation of the cylinder of the gyro steering engine, and is cast in one mass with the frame. It is open at the outer end, but closed at the cushion end by a thick diaphragm separating it from the gyro steering engine. The piston is a stout plunger fitted to work nicely in the cylinder, being sufficiently air tight without packing rings. Its middle is partly cut away, and both the cylinder and piston are slotted for the action of the stop arm.

THE VALVE MECHANISM.

472. Where is air drawn from for use of this mechanism?	From the reducing valve of the valve group at the running pressure of the main engine.
473. How and to what pressure is it further reduced?	By the reducing valve to about 300 pounds.
474. What does the valve mechanism consist of?	The valve body, the valve plug, and the valve.
475. Describe the passage of air through the valve mechanism?	Air supplied by the channel to the annular groove around the valve plug, from which it passes through channels to an annular groove around the valve. Two longitudinal surface channels on the valve carry the air both upward and downward, where it is arrested and awaits further movement, to be determined by operation of the valve.
476. What will be the movement of the piston of the steering engine if the valve is turned to the right?	The piston will be forced aft, which will put the rudder to port.
477. Where is the exhaust for the steering engine?	Through a central longitudinal orifice in the valve exhausting directly into the after body of the torpedo.
478. How is the valve body shaped?	It is reamed to form a cone-shaped cavity into which the valve plug fits practically air-tight without packing.
479. How is the valve plug shaped?	It is coned to fit the recess of the valve body. It is of rectangular shape at the top and provided with holes through which pass the valve body studs by which the valve plug is kept seated. The valve plug has an axial cylindrical hole in which fits. with great nicety the valve, working practically air-tight without packing.

THE GYRO MECHANISM—Continued.

THE VALVE MECHANISM—Continued.

Question.	Answer.
480. How is the valve shaped?	It is a plain cylinder having an axial hole its entire length. The lower portion is fitted for the valve action, and the upper portion constitutes a stem for the application of the valve arm.
481. What is the valve arm and how fitted?	The valve arm is a steel piece of rectangular section at the upper end, and fitted with 2 holes, through 1 of which the upper end of the valve passes, and through the other a set screw by which the 2 pieces are held together. The metal is then thinned and bent downward, and fashioned at its lower end to the form of a yoke that embraces the control pin when the parts are assembled for action. At the middle of the yoke a small slot is cut in which the control pin works to operate the valve. When by the mutual action of the control pin and the valve arm the limit of useful valve motion has been given, the control pin passes out of the slot, and the horns of the yoke being curved to the same arc upon which the control pin travels, no further valve motion ensues until by return action the horn of the yoke has guided the control pin into the slot.
482. What is the valve guard and its office?	The valve guard is a small piece of sheet brass bent to conform in shape to the valve arm. In its upper portion are 2 holes through which the valve-body studs pass. It is held in place just clearing the top of the valve by the stud nuts. In adjusting it to this position it bears upon the valve-plug springs, previously dropped over the studs. A small hole directly over the axial hole of the valve permits free exhaust. The office of the valve guard is to keep the valve plug seated, prevent the valve from rising out of place, and to protect the valve arm from injury in handling.
483. How is the valve mechanism assembled?	This should be done with the instrument in the adjusting stand. The valve plug is entered in the valve body and adjusted to its approximate mid position by the valve-plug adjusting screw. Place the valve-plug springs in position. Pass the valve through the valve arm to its approximate position and enter it into the valve plug without clamping the arm to the valve. The yoke of the valve arm should be in position embracing the control pin, and the latter should be held in its true gyroscopic position by the centering stud and position holder. Put on the valve guard and seat it with the stud nuts. Pin the bar of the adjustment stand central and see that the valve-arm clamp screw is slack. Now admit air and move the valve-adjusting screws until the mid point is found, from which the engine works freely both ways. Clamp the arm to the valve.

THE GYRO MECHANISM—Continued.

THE GYRO STEERING ENGINE.

Question.	Answer.
4. Describe the gyro steering engine.	The gyro steering engine is a simple cylinder of $\frac{3}{4}$-inch diameter and $\frac{9}{16}$-inch stroke. The piston is $\frac{23}{32}$-inch in length and fits practically air-tight without packing. The piston rod is fitted with a flange at one end, by which it is firmly held by the steering-rod coupling, and a smaller flange at the other end connects it with the piston.

THE GYRO FRAME.

5. Describe the gyro frame.	The frame is an irregular shaped casting upon which are mounted and assembled the gyroscope and the impulse sector, together with the accessory parts involved in their operation. The valve body, the gyro steering engine, and the air-cushion cylinder are cast as parts of the frame. Two stout lugs are provided for securing the frame to the pedestals of the door jamb, and smaller lugs provide bearings for the light rock shafts and accessories.

THE HORIZONTAL ROCK SHAFT.

6. Describe the horizontal rock shaft.	The horizontal rock shaft carries at one end the position arm that operates the position holder. Near the middle is the cocking toe, which engages with the cam, holding the impulse sector at cock after winding. At the other end is the trigger, against which the lower arm of the releasing lever presses when the torpedo is launched, withdrawing the cocking toe and releasing the cam, thus permitting the impulse to be given.

THE POSITION HOLDER.

7. Describe the position holder and its use.	It is a small piece of sheet brass, fashioned at one end as a clutch to partially embrace the 2 gimbal rings and thus hold the gyroscope in proper position for receiving the impulse.
8. What does it receive motion from?	The position arm.
9. Through what medium?	A wire link.

THE GYRO MECHANISM—Continued.

THE VERTICAL ROCK SHAFT.

Question.	Answer.
490. What is carried at one end of the vertical rock shaft?	The centering arm, fitted at its extremity with a centering stud.
491. Into what does the stud enter?	A conical recess in the steel center that carries the forward end of the axle of the gyroscope wheel
492. What is the purpose of the centering stud?	To accurately center and support the wheel of the gyroscope while it is receiving the impulse.
493. What removes the stud from the axle of the wheel as soon as the impulse has been given?	A boss on the impulse sector acting upon the boss arm of the vertical rock shaft.

THE ROCK-SHAFT SPRING.

494. What is the use of the rock-shaft spring?	To hold and center the gyroscope, through the position holder, and the centering stud.

THE RELEASING MECHANISM.

495. Describe the action of the releasing mechanism?	The releasing mechanism of the gyro gear takes its initial action from the upper arm of the bell crank on the valve group. When the starting lever is thrown back in the operation of launching, the upper arm of the bell crank moves aft. To this arm is pinned a short link, the other end of which is pinned to the forward end of the push rod. The push rod passes through the stuffing box of the engine-room bulkhead, and its after end presses against the upper arm of the releasing lever. The releasing lever is a vertical rod in the forward part of the after body, pivoting in brackets and operating as a rock shaft. It has an upper and a lower arm of about equal length. When the push rod bears against the upper arm, the lower arm, carrying the adjustable head, presses against the trigger of the gyro gear, releasing the cam and permitting the impulse spring to give its action.

THE GYRO REDUCING VALVE.

496. Describe the gyro reducing valve.	Air enters at the nipple on the end of the valve casing, passes into the axial channel of the valve through the radial holes, and emerges into the pressure chamber through the axial hole in the screw.

THE GYRO MECHANISM—Continued.

THE GYRO REDUCING VALVE—Continued.

Question.	Answer.
	The diaphragm is of thin German silver, and is held on the seat by the cover and to the valve by the screw. The pressure in the chamber causes the diaphragm to yield, owing to its pliability, and as it buckles downward it forces the valve downward until it is fully seated upon the valve face. Supply air is thus cut off until the pressure in the chamber is sufficiently reduced by the gyro steering engine through the nipple, when the valve again opens, admitting air. A hole permits the free escape of air that may leak by the valve into the chamber. If necessary, a paper washer may be laid on the seat under the diaphragm. Increasing the thickness of this washer makes the valve more difficult to seat, and hence gives greater average working pressure. The valves are adjusted in manufacture to work at 300 pounds.
7. Describe the modified reducing valve.	The body of the modified reducing valve, of bronze composition, is cylindrical and open at both ends. The lower end is closed, air tight, by a screw plug against a porpoise-hide washer. The upper end is closed by a screw plug whose lower face bears against a small spiral compression spring, the other end of which rests on the upper end of the plunger of the reducing valve. On the exterior face are cast two nipples, communicating with the interior, for air-pipe connections. On the interior surface are two ribs, a broad one on the surface of which works, air tight, the plunger, and a narrow one, the shoulder of which forms a seat for the valve. The valve seats face upward. The operation is as follows: Screwing down the plug, the amount to be regulated according to the working pressure desired for the gyro steering engine, forces the valve from its seat. Air enters through the nipple, at the working pressure of the main engine, passes through the valve opening, where it is reduced to the desired pressure, and thence, through the nipple, to the gyro steering engine. Should the pressure exceed the desired amount, then, acting upon the lower face of the valve, it will seat the valve until the gyro steering engine reduces it to the desired amount, when the valve will open again. Air leaking by the plunger into the upper space escapes through a small opening.

CHAPTER IV.

ASSEMBLING TEST.

QUESTION.	ANSWER.
498. Give the 10 assembling tests in their order.	(1) Remove the stop, charging, reducing, and controlling valves and thoroughly clean and oil them. The stop and charging valves can easily be made tight by grinding in with oil and a little finely ground glass (never use emery). Never put more than a moderate pressure on the stop valve, as it is apt to set. When opening it for a run, screw the spindle full distance up, as otherwise there is apt to be an air leak around it. The plug in the top of the reducing valve is liable to work loose and should be tightened if necessary. (2) See that the setting of the depth index corresponds to the required pressure on the hydrostatic piston. With the depth index set at 5 feet, a pressure of 28.8 pounds should move the piston. Double this pressure should correspond to a setting of 10 feet. This test is conveniently made with a push spring balance. (3) See that the locking mechanism is in good working order. (4) See that the equalizing springs of the pendulum permit free movement at an inclination of $2\frac{1}{2}°$ to $3°$. (5) Sling the air flask and ascertain by balancing whether or not it is free from water. Water should be drained from the flask only when the after body is off, to avoid having dirt or sediment pass through to the valve group. To do this, first remove the charging and check valves and open stop valve to permit the escape of any air that may be remaining under pressure in the flask. Then remove the stop valve and sling the flask so that the air pipe shall be at the lowest point, thus allowing the water to run out. After draining, thoroughly clean the valve seats and replace the valves, and when the flask is charged for testing, blow through before connecting the testing pipe. (6) Charge the air flask to at least 700 pounds pressure and connect the air pipe to the valve group by the testing pipe. (7) See that the lock is on the propeller. (NOTE.—The lock is to be habitually kept on the propeller. The stop valve is always to be kept closed and starting lever forward except when using air.) Open the stop valve half a turn, give a slight compression of about 2 turns to the regulator spring and set the distance gear sector 2 or 3

ASSEMBLING TEST—Continued.

Question.	Answer.
	teeth; in the 5m., Mark II, compress the reducing valve spring slightly and turn the distance index pointer a very little to the right. Lift the starting lever slightly and make a thorough examination for air leaks (1) at the top of the valve group around the follower, (2) at the joint between the valve group and the engine, (3) around the spindle of the controlling valve (a slight leak here is unavoidable), (4) at ends of valve chest and cylinder heads. (5) around joints of air pipes to oil cup and steering engine, (6) around the crank case cover and plugs in the engine body, (7) around the packing in the end of the steering engine and through the steering engine valve, (8) at the bulkhead joint of the air pipe into the immersion chamber, (9) in the air system of the gyro gear. The best way to detect leaks is, with the torpedo charged and propeller lock on, to place it in the water and push it a little under the surface. Rising bubbles will indicate a leak and its locality. *Whenever using a lighted taper be careful not to heat springs and so injure the temper of them.* Leaks can generally be stopped by more carefully adjusting the air joints and valves. *Air joints must be tightened evenly. If the flange is tightened more on one side than on the other it will not fit evenly on the knife edge and will leak. Lead washers are not to be used in place of the leather washers supplied.* (Note.—Lighted tapers should not be used except where absolutely unavoidable. They are liable to injure the springs, soften the paint, and cover parts of the mechanism with soot and dirt. Air leaks should be detected and remedied before the after body is joined up, and one that can not be detected by sound is not apt to be serious. To examine the interior, for making adjustments, etc., the lamps furnished with the torpedo outfit thould always be used if possible.)
	(8) Make sure that the steering rod permits sufficient throw by moving the rudder up and down by hand. The pointer should show at least 4 divisions down and $3\frac{1}{2}$ up. See also that the steering engine works freely and gives full throw. (To put on the pointer see that the horizontal rudder is in the same plane as the horizontal tail blades by using a straightedge Then clamp the pointer in place so that it points to the zero of the scale.)
	(9) Connect the after body to the flask and make tight the air joints at the valve group.
	(10) Fill and attach exercise head, or prepare war head if for war shot. If a war shot is to be made, the dry primer, with war nose and exploder, are not to be put in the war head until just as the torpedo is on the point of entering the tube.

ASSEMBLING TEST—Continued.

Question.	Answer.
	FIRING TESTS AND ADJUSTMENTS. When the torpedo is ready to enter the tube th following final tests and adjustments are to b made before shoving it home. If for the firs practice after the torpedo has been received o board, the adjustments will be made in accordance with those on the adjustment card furnishe with each torpedo; otherwise consult the Recor of Practice sheet. The columns of this sheet which are to be filled out at each run of ever torpedo, will be a guide in making the fina adjustments.

PREPARATION FOR FIRING.

508. Give the 20 steps for preparation for firing in their order.	(1) Try tripping latch and stop pin and be carefu that stop pin is down with safety pin in plac before entering the torpedo. If for war sho prime the war head. Enter the torpedo into th tube until the stop valve is just clear of the tube (2) Remove the charging valve of torpedo, ope stop valve, screw in wing nut of charging pipe and charge flask to about 700 pounds for testing (3) With starting lever back, test all air connections, engine and valve plugs, etc., for leaks using a lighted taper. (4) Put a little oil in the cups, oil after bearings take off propeller lock, raise water tripper, and then test distance and locking gear by running the engines, placing a tarpaulin to catch the oi blown through. Put on propeller lock. In making this test, set distance gear sector for 1 tooth and give the regulator plug about 2 turns down from flush position, for all marks of torpedoes except the 5m., Mark II. In this one compress the reducing valve spring 2 or 3 turns and turn the index pointer slightly to the right. To lock the rudder: in 3.55m., Marks I and II, push down the ratchet bar 2 teeth by means of tool No. 9 through a hole in the top of the shell of the torpedo; in 3.55m., Mark III and 5m., Marks I and II, using tool No. 48, unclamp and turn the locking adjustment index 2 graduations to the left and clamp it; then turn the outer bevel gear sector to the left until the tool brings up against the index. (5) See that propeller lock is on. Test horizontal rudder for full throw by hand and by steering engine. See that it works freely. This test is the same for all marks of torpedoes, except that with 3.55m., Marks I, II, and III, use tool No. 40 with permanent scale on after vertical blade and with 5m., Marks I and II, use tools Nos. 44

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

Question.	Answer.
	and 45. With air on the engine and the horizontal rudder exactly level, and with tool No. 9, for 3.55m., Marks I and II, and tool No. 10 on adjusting nut for 3.55m., Mark III, and 5m., Marks I and II, inserted through hole in the side of the shell of the torpedo, move the valve stem of the steering engine back and forth to its limit. The throw of the rudder should be at least 4 divisions down and 3½ up. (Put on pointer as before described.)
	(6) Test horizontal rudder for effect of hydrostatic piston and get correct difference of throw. The *down* throw due to piston *out* should exceed by about one-fourth of a division the *up* throw due to piston *in*. To test piston: In 3.55m., Mark I, enter tool No. 36 in hole on starboard side of torpedo, bring the bent arm against the after face of piston, and with starting lever aft and depth index registering 5 feet, press down to obtain *up* throw and release the pressure to obtain *down* throw of rudder; in 3.55m., Marks II and III, and 5m., Marks I and II, using tool No. 37, turn operating spindle of depth index to the left until it binds, for piston *in* and *up* throw; turn it to the right until the index registers a depth of 5 feet for piston *out* and *down* throw of rudder. To get correct throw, use the valve star in 3.55m., Marks I and II, and the adjusting screw in 3.55m., Mark III, and 5m., Marks I and II.
	(7) Adjust gyro gear and put same in place in the torpedo, and make sure that the vertical rudders work freely and give proper throw. In putting the gyro gear into place be careful not to omit the leather washer in the air-pipe connection on the frame lug. Be sure that the vertical rudders are unlocked from the midship position and connected to the after end of the gyro steering rod. To adjust the gyro gear: Screw the gear to the adjusting stand, connecting the valve stem to the testing tiller rod. Put in the gyroscope wheel, entering the forward pivot, which should not have been disturbed when dismounted, screwing in the after pivot, finger taut, and setting up on the clamp screws of the counter balance center. See that it runs freely; oil bearings of the wheel. Swing the starting lever (on the stand) around in the direction of the hands of a watch as far as it will go. Wind up the gyro, noting that the impulse sector meshes properly with the teeth of the gyroscope axle. Trip the impulse spring by swinging back the starting lever (on the stand) and note the run of the wheel. If the after center, on which the counter balance is screwed, has horizontal

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

Question.	Answer.
	motion in a direction contrary to the hands o watch, the counter balance is too far from t center of the system, producing too great effect, and must be screwed toward the ring. the motion is with the hands of a watch, t counter balance is too near the center of t system and must be screwed out from the ri *When the counter balance is properly adjusted, must be secured in place by the jam nut.* If t lateral movement of the wheel can not be c rected by moving the counter balance in or o the wheel itself will have to be moved in or o as the case may be, by means of the adjustal screw pivots through the inner ring into the co shaped bearings in the ends of its axis. T wheel is very sensitive to this adjustment, a it must be carefully made. After making it, s that the wheel turns freely on its axis and set the clamp screws. To adjust the valve: Connect the testing pipe wi the gyro reducing valve in the torpedo; wind and start gyro as before; remove the centering p in the adjusting arm and work the frame back a forth, to get an indicator diagram. If the diagra shows that the torpedo would deflect, due to t action of the gyro, counteract this tendency turning the valve plug by means of the adjusti screws. One screw must be slackened before t other can be screwed in. The torpedo will r in the direction in which the screws are move (8) Adjust the torpedo mechanism for a run, usi the adjustment card furnished with the torpe (or the Record of Practice sheet): (*a*) Set the regulator. The upper face of t screw plug being flush with the top of the reg lator body, screw it down the number of tur indicated by the adjustment card for the distan to be run. In the 5m., Mark II, make this adjus ment with the adjusting sleeve nut just beari on, without compressing, the reducing val spring. (*b*) Set distance gear sector, *being careful to have ca pin against the stud on the sector.* With the ze on the sector opposite the pointer in the engi room door and the socket wrench on the adjus ing spindle, set the sector at the number of tee indicated by the adjustment card for the distan to be run. One turn of the socket wrench giv one tooth on the distance sector. In making th adjustment be careful not to turn the wrenc the wrong way. It should be turned *again* the hands of a watch.

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

Question.	Answer.
	In the 5m., Mark II, turn the index pointer to the mark on the distance gear cylinder indicating the number of yards desired for the run. (*c*) Set depth index. With socket wrench turn the spindle until the index shows required depth, generally from 5 to 7 feet. *Set up clamp nut tight*, as otherwise the immersion chamber will be flooded at the end of the run and the torpedo will sink. (*d*) Set vertical vanes. Divisions to right or left shown on adjustment card. (On some of the printed torpedo forms are instructions to set the vertical vanes at zero when the gyro is used. This is incorrect. The setting of the vanes which is found to give a straight run without the gyro should be maintained when the gear is used, in order that the gear may be given a perfectly balanced torpedo to control and not one in which there is an initial deviation.) (*e*) Lock rudder for time and position. Before attempting to lock the rudder, place it about horizontal, as otherwise the locking lever may not fall into the locking jaws. The rudder should remain locked until the speed of the torpedo has become somewhat uniform and the pendulum is able to exercise its normal function. It will require a distance of from 50 to 75 yards to accomplish this. One tooth on the ratchet bar gives about 7 yards, and one division on the locking adjustment index gives about 9 yards. Locking for position means maintaining the rudder up, or down, or horizontal while it is locked for time. This position of the rudder depends somewhat upon the circumstances of the dive; with a high dive, or shallow water, up rudder may be advisable; with a low dive or deep water, down rudder may be necessary. Ordinarily, however, and especially with the flat dive necessitated by the gyro gear, the rudder may be locked horizontal. The rudder is horizontal when the zero on the adjustment cam index coincides with the reference mark on the index washer. Lock the rudder for time as in testing the locking gear, explained above. To lock for position use the locking star in 3.55m., Marks I and II; in 3.55m., Mark III, and 5m.; Marks I and II, slack up the lock nut, or screw, turn the adjustment cam sleeve the required number of graduations, as shown on the index, and set up on the lock nut. Ten points of the locking star and twelve divisions of the adjustment cam index change the rudder about one division. Both these adjustments are taken from the adjustment card.

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

QUESTION.	ANSWER.
	(*f*) If for action hook up sinking gear and take ou drain plugs in after-body. Removing the drai plugs is sufficient. It will be found that if on of the drain plugs is removed from the after-body little if any water will enter while the torpedo i at full speed, but at the end of the run sufficien water, especially with the later marks of torpe does, will enter to sink the torpedo. (9) Charge flask to firing pressure and replac charging valve. If air impulse is to be used charge air reservoir to required pressure. (10) Be careful that starting lever is down an wind the gyro gear. The starting lever mus *not* be raised after this is done. (11) Drain after-body and immersion chamber an replace drain plugs. (12) Oil up carefully, filling cups. (13) See that stop valve is open. Screw the spin dle full distance up. (14) Raise water tripper. (Not done for war shot nor in submerged discharge.) (15) Try stop pin and tripping latch, and shov torpedo home with loading staff, being careful t have stop pin *down* and tripping latch *up*. (16) Be sure that the tripping latch is down befor the torpedo is fired, as otherwise the startin lever will not be lifted and the torpedo will no run. It has been found advisable, in man cases, to remove from the tube the pin by whic the tripping latch is held up, thus necessitatin holding it up by the hand while the torpedo i being shoved home, and removing the possi bility of its remaining up until the torpedo i fired. (17) Remove propeller lock and rudder index turn engines off the center; and close the doo of the tube. (18) Open torpedo port. (In time of war not to b done until within torpedo range, and then onl at order of officer in command.) (19) See safety pin in place. Enter impulse charg and primer. (The primer is never to be entere and connected until the torpedo port is open.) (20) Depress the tube, degrees. REMARKS ON TESTS AND ADJUSTMENTS. *Oiling.*—This is very important, oil being bot lubricant and packing. Fill all oil cups, oi water tripper, shaft bearings, and rudder con nections. Oiling must never be neglected, whether for tests or for actual runs.

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

Question.	Answer.
	REMARKS ON TESTS AND ADJUSTMETS—cont'd.
	Propeller lock.—The propeller lock should be kept on at all times, except when the torpedo has been put into the tube for firing, or when blowing off after a run, or when testing the distance and locking gears.
	Water tripper.—The water tripper should always be raised when the engine is turned by air out of the water, and before actual firing except for submerged discharge and war runs. It should be well oiled and must move freely.
	Rudder throw.—The total throw of the horizontal rudder, about 20° for 3.55m., Marks I, II, and III, and about 25° for 5m., Marks I and II, is measured by a scale, divided into 8 divisions, 4 on each side of the zero, on the port after top blade of 3.55m., Marks I, II, and III, and on the movable rudder scale (tool No. 44), in 5m., Marks I and II. With the rudder horizontal and the pointer on it marking zero on the scale, the steering rod must be of such a length as to allow a throw of 4 divisions down and 3½ up, as indicated by the pointer. That position of the piston in the cylinder of the steering engine that permits this division of the total throw is the zero, or reference, position. This is a shop adjustment and should be permanent. In disassembling the after-body the turns taken in unscrewing the steering rod must be carefully noted, and exactly the same number taken when screwing it in, upon reassembling. A mistake is easily made in doing this, for the first turn or so counted may not take the thread. Before connecting up the after-body, move the rudder up and down first by hand, and then with air on the steering engine through the testing pipe, and see that it has full throw of 4 divisions down and 3½ up, and that all parts work smoothly and freely.
	The throw of the rudder due to the hydrostatic piston is about 3¼ divisions on the scale, 1½ divisions *up* throw for piston *in* and 1¾ *down* throw for piston *out*. In balancing the rudder for piston effect, it having been already balanced for full throw, the adjustments must be made with the valve star or valve adjusting screw, according to the mark of the torpedo.
	When testing the horizontal rudder for full throw, if it does not balance properly the fault lies with the steering rod, and can only be corrected by lengthening or shortening the rod, as the case may be. If the error is sufficiently serious to

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

QUESTION.	ANSWER.
	REMARKS ON TESTS AND ADJUSTMENTS—cont'd.

affect the run of the torpedo, the tail must be dis connected and the rod lengthened or shortened b screwing it out or in. One turn of the steerin rod will change the throw of the rudder $\frac{3}{4}$ of division. When testing for piston effect, th proper balance of throw, about $\frac{1}{4}$ of a divisio more down than up, must be obtained by length ening or shortening the valve stem, as the cas may be, by means of the valve star or the valv adjusting screw. Turning the points of the valv star up in 3.55m., Mark I, and down in 3.55m. Mark II, will shorten the valve stem. Turnin the valve adjusting screw to the right wil lengthen the valve stem.

To test the combined effect of the hydrostati piston and pendulum, sling the torpedo and us a spirit level. With the torpedo horizontal, o inclined at an angle less than $2\frac{1}{2}°$ to $3°$, only th hydrostatic piston should have an effect on th rudder; as the inclination is increased the pen dulum will cooperate to lessen or increase th throw until the limit is reached. Suppose th full throw to be 4 divisions down and $3\frac{1}{2}$ up, an the throw due to the piston to be $1\frac{3}{4}$ down and 1 up. Incline the torpedo, tail upward; with th piston *out* the extreme up throw of the rudde will be $3\frac{1}{2}-1\frac{3}{4}=1\frac{3}{4}$ divisions, and with piston *i* it will be $3\frac{1}{2}$ divisions. Incline the torpedo, tai downward; with the piston *out* the extrem down throw of the rudder will be 4 divisions, an with piston *in* it will be $4-1\frac{1}{2}=2\frac{1}{2}$ divisions.

In making tests for balancing the rudder, consider able discretion must be used in noting the rudde throw. Its action is more or less uncertain owing to the wear of the pivots, etc., air leakin in the steering engine, or dryness of valve.

In balancing the hydrostatic piston in 3.55m. Mark I, torpedoes care must be taken not t injure the rubber diaphragm.

MISCELLANEOUS.

Initial dive.—This is determined by height of tube depression of tube, length of spoon, velocity o ejection, and the position and duration of locke rudder. Assuming the height of tube, lengt of spoon, an impulse charge, as constant, to deep diving may be corrected by lessening th tube depression, or by locking the rudder up or for a longer time; too shallow diving, by in creasing the tube depression, or by locking th

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

Question.	Answer.
	MISCELLANEOUS—continued. rudder down, or for a shorter time. (The tube mount must be securely clamped to prevent excessive jump.) The 3.55m., Marks I and II, torpedoes are not fitted for the flat dive. The 3.55m., Mark III, torpedoes have had extra guide studs fitted just forward of the stop valve, thus giving the flat dive. The 5m. central pivot tubes have all had their spoons lengthened, so that the 5m., Mark I, torpedo will dive flat from them but not from lower deck tubes. *Depression of tube.*—This and the speed of ejection due to the impulse charge affect the entry of the torpedo into the water. When the axis of the tube is less than 5 feet above the water, an extreme depression of 6° may be given; when more than 8 feet above the water, little if any depression; when between 5 and 8 feet, a mean proportional depression. (These values are to be regarded merely as rough approximations, and must be determined for each tube.) In torpedo tubes fitted for the flat dive it seems that a fixed depression of about 2° gives the best results. It is not enough to bring undue strain on the pendulum checking springs; and yet it facilitates the entry of the torpedo into the water and in so far probably lessens the strain brought on the tail and at the same time secures the benefits of a flat dive for the gyro gear. *Tube recoil.*—Unless on a solid mount and securely clamped, the tube will recoil and affect the torpedo's entry into the water. *Impulse charge.*—For the small Whitehead, the charge weighs 4 ounces; for the large Whitehead, 7 ounces. When making up the small charge, first put 7 powder grains of sphero-hexagonal powder in the cartridge case and then 21 powder grains of the cubical black powder, of the kind used in Hotchkiss rapid-fire guns. For the large torpedo, first, 12 sphero-hexagonal grains and then 35 cubical black. Jam the wad in the end of the cartridge case, and if not to be used immediately, protect from moisture by using wax and shellac around edge of wad, and put plug in the end of primer pocket. Keep cartridges in dry place. *Cartridge block.*—If the bottom of the cartridge block becomes coated with residue, it will prevent the block being turned to the full locked position.

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

Question.	Answer.
	MISCELLANEOUS—continued.
	Firing mechanism.—Should be tested after the torpedo has been shoved home. Care should be taken to see that the friction primer is a neat fit, with no lost motion in loop of primer, and that a straight pull is obtained; otherwise with friction primers miss fires are very apt to occur.
	Packing band.—If the tube has a packing band, the band must be central or deflection will result; it must be tight around the torpedo or the impulse charge will not produce uniform results. Its tightness should be such that the force of two men on the loading staff is required to shove the torpedo home.
	Air flask with removable head.—The 5m., Mark II, torpedo has its air flask fitted with the forward head removable, to enable the interior of the flask to be cleaned when necessary, the object being to prevent the accumulation of rust and scale in the flask, the carrying over of particles thereof into the mechanism, and the consequent failure of a run.
	As the removable head fits into the flask upon ground surfaces, great care must be exercised in removing and replacing it, and these instructions must be rigidly adhered to.
	The head should never be removed from the flask on board ship except in case of urgent necessity, but this work will ordinarily be done by skilled laborers at shore stations. No torpedo should be allowed to go longer than three years without having the interior of its flask cleaned at a proper shore station, and when so cleaned a note of the date and condition should be entered on the torpedo record.
	Two phosphor-bronze protecting rings are furnished with each outfit, to cover the ground surfaces in the flask and on the head, and these must be screwed into place as soon as the head is removed, to remain in place until just before the head is replaced.
	No waste should be used for wiping the ground surfaces clean, but a soft cloth free from ravelings, and the greatest care must be exercised at all times to avoid scratching or marring the surfaces.
	To insert the air flask head, place the plane of the head parallel to the axis of the flask, the small "flats" opposite the grooves in the end of the flask. Push the head completely into the flask, then turn it the proper amount and bring it up against its seat. Then put in the holding screws. To withdraw the head reverse the operation.

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

Question.	Answer.
	MISCELLANEOUS—continued.
	Initial dive effect on the gyro steering device.—The 3.55m., Mark III, and 5m., Marks I and II, torpedoes are fitted with the gyro gear, and they require a flat dive. Unless the dive be flat it is possible that the vessel's speed might throw the tail of the torpedo far enough forward to cause the gyro position holder to strike the outer gimbal and make the gyroscope tumble. When new torpedoes are received from the maker, special precautions are taken not to disturb the gyro gear adjustments used on acceptance trials. It is deemed advisable, however, after receiving and assembling these torpedoes on board, to run them at least once before depending on them for a war shot. If the gyro and all other adjustments are properly made, no deflection will be caused by the speed of the vessel. Even if the torpedo broaches after initial dive the gyro will correct the course and give a straight run.
9. How is the gyro tested while in the torpedo?	See the starting lever down, the lock on the propellers and raise the water tripper. Put the transporting strap on, and sling the torpedo that it may be swung in azimuth. Wind the gyro. Raise the starting lever, which starts the gyroscope wheel spinning by releasing the impulse spring. Swing the tail of the torpedo gently from side to side, and note the angle, or arc, through which the tail moves when the vertical rudders move from one side of the torpedo to the other. If the gyro is working properly the rudders should move from one side to the other when the tail is swung through an arc of 1° (one-half degree each side of the central position); the extreme limit within which it is necessary to move the tail to work the rudders might very properly be considered as not more than 3° of arc ($1\frac{1}{2}$° each side of central position). It should, however, be less than this. Continue to swing the torpedo to the right and left for four or five minutes, and notice if the limiting points of the arc through which the tail is swung remain constant, or if it is necessary to swing the torpedo a little farther to the right or left each time. If the latter is the case, and the ship is steady, then the gyroscope wheel is probably not keeping in the same plane as it should. It will therefore be necessary to adjust the gyro.

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

Question.	Answer.
500. How is the gyro gear adjusted?	Take out the screws of the gyro door and remove the door. Unscrew the holding-down screws of the gyro, with a socket wrench, and lift the gyro out of the torpedo. Put it in the frame of the adjusting stand and screw in the holding-down screws. Swing the starting lever (on the adjusting stand) around in the direction of the hands of a watch as far as it will go. Wind the gyro, noting that the impulse sector meshes properly with the teeth on the gyroscope axle. Have a watch ready to note the duration of the time the gyro will run. Trip the impulse spring by moving the starting lever back in the opposite direction to the motion of the hands of a watch, seeing that it remains in the position to which moved and does not fly back. Set a pointer on the stand, close to the end of the center on which the counterbalance is screwed, so that its motion (if any) may be carefully noted. (This is the after center on which the gyroscope wheel turns when the gyro is in the torpedo.) If the center moves to the left (against the hands of a watch), the counterbalance is too heavy, and must be screwed toward the ring. If the after center moves to the right, the counterbalance is not exerting weight enough on the wheel, and must be screwed out. If the horizontal motion to right or left of the after center can not be overcome by moving the counterbalance toward the ring, or out to the end of the screw upon which it is screwed, then the gyroscope wheel itself will have to be moved in the same direction. To do this slacken the clamp screws of both centers, unscrew one center about one quarter of a turn, then screw the other one in carefully the same amount. The wheel will be found very sensitive to this adjustment. See that the wheel turns freely on its centers, then set up the clamp screws. Wind up the gyro and try the running of the wheel again. Continue the operation until there is no horizontal motion of the centers of the wheel, and, of course, of the wheel itself. If the centers of the gyroscope wheel have a vertical motion, after the horizontal motion has been overcome, it probably indicates that the gyroscope wheel is too near the ring bearing of one of its centers, and too far away from the other one. Moving it back to the proper position would introduce a horizontal motion of its centers. The ver-

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

Question.	Answer.
	tical motion would probably not interfere with the proper action of the gyro, however (unless the torpedo rolled), except in cases when it was so marked that the wheel had turned up to a position where the gyroscopic action was interfered with before the torpedo had finished its run. The vertical motion might be overcome by moving the wheel in the direction of its centers until in the proper position, and then filing from the heavier side of the ring. The wheel is nearer the ring bearing of that center which has a vertical motion upward when the wheel is running. Having adjusted the gyroscope so that the centers of the wheel do not move in azimuth while the wheel is running, make the air connections and turn on a pressure of about 300 pounds on the steering engine. Wind up and start the gyro, and then work the frame of the adjusting stand back and forth to get an indicator diagram. This will show the action of the rolling valve of the steering engine. Excellent cards have been taken by moving the frame through an arc of 1° (one-half degree each side of the center). If the card shows that the torpedo would have a tendency to run either to port or starboard of the line of sight (through the action of the gyro), counteract this tendency by setting the valve plug by the adjusting screws. One screw must be slacked up before the other can be screwed in. The torpedo will run in the direction in which the screws are moved. In adjusting the gyro gear care must be taken that the exhaust air from the gyro steering engine does not blow upon the gyroscope, from any cause. Should it do so, the result will be the same as if the gyroscope balance were not correct, and an otherwise correctly adjusted gyroscope may be put out of adjustment in an attempt to remedy the fault before its true nature is ascertained. This condition existing during a run will of course give a curved course to the torpedo. Air leaks near the gyroscope may give the same results.
1. How would you know when the gyro is in adjustment?	When the adjustments are so made that a symmetrical diagram is still obtained after working the adjusting arm back and forth continuously for 90 seconds, the torpedo will make an accurate run within a range of 1,500 yards and the adjustments may be considered to be satisfactory.

ASSEMBLING TEST—Continued.

PREPARATION FOR FIRING—Continued.

QUESTION.	ANSWER.
502. How can the impulse spring be tautened?	Take out the screws in the impulse sector stop, and take off the stop. Give the impulse spring one complete turn with the winding key, and, holding it in this position by the key, put on the stop again. Be careful to keep the fingers out of the holes through the impulse sector, or they might be cut off by the sector in case the key should slip. Be very careful not to bend the toes of the position holder in handling the gyro gear. This precaution is necessary in order to insure the proper seating of the position holder in winding up the gear. If the position holder does not hold the gyroscope up to proper position for the centering stud, the gear may be wound up so that, when tripped, the impulse sector will not engage the teeth of the gyroscope; and this will cause an abnormal blow upon the stop, stop arm, and air cushion sufficient to bend the cam shaft and impulse sector, thus rendering the gear useless.
503. What care must be taken with the gyro gear?	The gyro gear should be handled with great care to keep it in adjustment and prevent injury to its delicate mechanism. It should be inspected frequently and the steel parts kept free from rust and well oiled. Particular attention should be paid to the steel centers, and especial care taken that the steel bearings of the gyroscope wheel are kept free from dirt and rust, as either would interfere seriously with the duration of a run of the wheel.
504. What are the special precautions concerning a gyro?	It is very essential that before discharging the torpedo with a war charge, the reducing valve and controlling valve and passages of the gyro gear shall be known to work freely and not be rendered inoperative through the presence of dirt, verdigris, or gumming oil, and that the rudders are in perfectly free working order, and not cramped by rust or from the packing around the rudder rod being set up too tight.

ASSEMBLING TEST—Continued.

DISEASES AND CASUALTIES.

Question.	Answer.
5. What are those that are most commonly met with?	Broaching, running away, short run, running slowly, striking bottom, sinking, deflecting, indentations in the head, leaks in the air flask, leaky stop and charging valves, air pipe leaking, pendulum out of adjustment, hydrostatic piston out of adjustment, immersion chamber leaking, distance and locking gear failing to work, engines broken down, steering engine failing to work, indentations in after-body, tail damaged, propellers jammed.
6. Describe briefly the causes for the above in order named.	*Broaching.*—The torpedo may broach on the initial dive or before becoming unlocked. Especially is this likely to occur in cases of a high velocity of discharge and a flat dive. This may be remedied by locking the rudder down or by locking with a less number of teeth, so that the rudder may become unlocked before the inertia of the pendulum is overcome, and the lag of the pendulum will cause the torpedo to take a deeper dive. The first remedy, especially in shallow water, is generally to be preferred. With a slow velocity of discharge and a sharp angle of dive the torpedo is not apt to broach before becoming unlocked, and it will not be necessary to lock the rudder down, unless it is to be kept locked too great a distance. In shallow water, under these conditions, it may be necessary to lock the rudder slightly up. With the flat dive it is recommended that under ordinary circumstances the locking be done with a very slight down rudder. If the rudder is kept locked too long, the torpedo will broach. A series of short broaches is indicative that the rudder has not become unlocked or only partly unlocked. Broaching after the torpedo has become unlocked may be due to several causes—the controlling valve of the steering engine may be stuck in the forward position; some foreign substance may be lodged in the valve of the steering engine; the follower of the steering-engine controlling valve may be partly unscrewed, not allowing full throw aft to the rudder; leak in steering engine either around the ends of the piston or past the piston rings; air passages in piston may be stopped up; the equalizing springs of the pendulum may be unequally adjusted, or the reducing valve may work in an irregular, jerky way, due to the valve binding or plug loose in top of reducing valve. If the fault lies with the diving mechanism, the sound of escaping air is unmistakable; in case the trouble is with the reducing valve, there is little or no sound of escaping air.

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ASSEMBLING TEST—Continued.

DISEASES AND CASUALTIES—Continued.

Question.	Answer.
	Too much up throw and not enough down will cause the torpedo to broach and run on the surface. If the spring on the steering rod is too stiff, it will also cause the torpedo to broach and run on the surface. Striking the bottom may sometimes cause the torpedo to broach. The torpedo may fail to broach at the end of its run, thus making it difficult to find, especially with the 3.55m., Mark III, which floats tail down. This results from a weakening of the spring which is supposed to throw the horizontal rudder hard up as soon as the engine stops. To remedy it, replace the spring. *Running away.*—This may be due to the distance gear failing to act. In this case also the locking gear is apt to fail, and, the rudder remaining locked, the torpedo will broach and run away on the surface; also, the reducing valve may stick, or some foreign substance under it may prevent its closing after the distance gear acts and cutting off air from the engine. *Short run.*—This may be due to the friction cam not being back to its full position, or the starting lever may not have been thrown back by the tripping latch, or the engines may have broken down or become stuck on the center. *Running slowly.*—This may be due to the starting lever being thrown only partly back on account of the incorrect adjustment of the tripping latch, or because of the water tripper not being thrown down when the torpedo enters the water. *Striking bottom.*—Unless the velocity of discharge, angle of dive, height of tube, depth of water, and locking the rudder are given due consideration, the torpedo is apt to strike the bottom, especially in shallow water. Five fathoms should be considered shallow water. *Sinking.*—This may be due, in a fully charged torpedo, to the starting lever failing to lift the valve, or a drain plug may be open, or the sinking valve may have been thrown off its seat. When recovered from sinking, the torpedo is to be thoroughly disassembled and cleaned, as dirt and grit will get into the engines and valves. If the depth-index plug was not set up tight after adjusting for depth, the immersion chamber will fill and the torpedo will sink. *Deflecting.*—This may be due to air leaks, or to running near or striking the bottom, or to the torpedo's rolling, or to the speed of the vessel, or to the incorrect setting of the vertical vanes.

ASSEMBLING TEST—Continued.

DISEASES AND CASUALTIES—Continued.

Question.	Answer.
	Aside from these, however, there is in general a tendency for every torpedo to deflect to the right. No sufficiently satisfactory explanation for this can be given. A torpedo fitted with a gyro gear in good working order will run in a straight line; if not so fitted, the tendency to deflect must be corrected by the vertical vanes. *Exercise head.*—Indentations from striking the bottom and from handling; loose brazing of the bulkhead ring from repeated shocks of firing and from striking the bottom. *Air flask.*—Slight leak through brazing of the forward bonnet; oily, fresh water, accumulated from frequent charges. *Stop and charging valves.*—Cracked casting; leaks due to dry valves, foreign substances, and worn washers. *Air pipe.*—Leak at the joint through the bulkhead of the immersion chamber. *Pendulum.*—Equalizing springs out of adjustment. *Hydrostatic piston.*—Spring out of adjustment for depth setting; leaks through the rubber diaphragm, cut by testing lever. *Immersion chamber.*—Leaks through defective gaskets, around the bulkhead, the hydrostatic piston, the depth-index and drain plugs, due to continued use; brazing around the bulkhead ring broken and leaking, due to repeated shocks of firing and striking the bottom. *Distance and locking gear.*—Ratchet bar bent, causing failure to unlock; tension on the springs of the locking lever and friction cam destroyed by use of lighted tapers; ratchet pawls worn and failed to work. Unless it is carefully watched in adjusting, the ratchet bar of the unlocking gear may not engage properly with its pinion in the valve group, and the horizontal rudder will then remain locked throughout the run. *Valve group.*—Leaky joints due to the knife-edge cutting an irregular seat in the air pipe and engine body; holding-down screws broken, due to setting up too hard; knife-edges of joints bruised in handling; retarding lever broken in launching and misplaced in assembling. The regulator springs by continued use had the ends burred and shortened from $\frac{1}{16}$ inch to $\frac{1}{8}$ inch, or from 1 to $1\frac{1}{2}$ turns of the lever; starting lever bent in slipping past a loose tripping latch; the spindle of the controlling valve worn and scored by grit, causing excessive leaks; screw in the top of the reducing valve worked loose; a piece of solder was blown through from the air pipe and lodged on top of controlling valve.

ASSEMBLING TEST—Continued.

DISEASES AND CASUALTIES—Continued.

Question.	Answer.
	Engines.—Broken down, due apparently to the pin of the crank brass breaking; the shaft bent out of line, due to the propeller catching a stone from the bottom; air leak through a pin blow hole in the casting of the engine body; the crank-case cover leaked, requiring a copper gasket 0.003 inch; the brazing of the cylinder head broken and leaking. *Steering engine.*—Clogged by dirt and grit, from being on bottom; piece of solder blown through from air pipe; set screw of the valve-star adjustment jarred loose and altered the correct position of the controlling valve; the controlling valve worn and scored, causing excessive leaks; the steering rod placed in wrong, due to the difficulty of counting the number of turns; steering rod bent and slightly shortened in launching; collar to the controlling valve unscrewed $1\frac{1}{2}$ turns; piston of steering engine unscrewed $\frac{1}{2}$ a turn. *After-body.*—Indentations from handling and small pin holes from interior corrosion; sinking valve jarred loose, due to striking the bottom. *Tail.*—Rudder bent in handling; considerable lost motion in the horizontal rudder—in some cases as much as $1\frac{1}{2}$ divisions—due to rust and wear in the pivots of the connection levers; all blades slightly warped and bent out of the horizontal and vertical axes of the torpedo, due to striking the bottom; the flat dive sometimes causes a bending up of the horizontal tail blades, but usually not more than can be readily straightened by hand. *Propellers.*—The set screw on a cone ring came out and jammed the propellers; blades nicked and distorted, due to striking the bottom.

GENERAL REMARKS.

507. What constant supervision must be exercised over torpedoes?	Constant supervision must be exercised over torpedoes to see that they are at all times protected from grit and kept clean, externally and internally; that the outer surfaces of shells are protected from rust by oil or vaseline; that the inner surfaces are protected from corrosion by a coating of paint of the kind hereinafter specified; that all interior parts are in thorough working order and well oiled on all working surfaces; that valves and air joints are kept free from grit and dirt and from deformation in handling; that steel screws, drain plugs, vertical vanes, rudder connections, guides for rudder connections and other steel

ASSEMBLING TEST—Continued.

GENERAL REMARKS—Continued.

Question.	Answer.
	parts are protected by oil or vaseline from rusting; that joint screws, stop valve, charging valves, drain plugs, and external steel screws are prevented from setting by being turned periodically; that the depth index and regulator springs be not given a permanent set by being kept in a state of compression for an undue length of time; that the releasing lever spring be released from tension when not in use, and that the shell and tail be protected from injury by blows or by violent handling.
. What kind of paint is used for the inner surfaces of the shells, etc.?	Spar varnish, known as *Vernosite*, with enough vermilion to give body and color.
. What kind of oil is used for lubrication and for cleaning the shell?	For lubrication use best winter strained sperm oil. For cleaning the shell lard oil with a small admixture of kerosene will be found efficient.
. In handling torpedoes where must the strain always be applied?	In handling torpedoes the strain in lifting must always be applied to the thicker part, the shell of the air flask, and never to the thinner shells of the head, or of the immersion chamber, or of the afterbody; and in landing torpedoes in the brackets, or on the trucks or chocks, the weight must be taken under the air flask, preferably near the heads of the flask, care being taken never to let the torpedo rest on the tail for even an instant.
. Where is the torpedo most sensitive, and what care must be taken in handling?	The tail is the sensitive part of the torpedo. Any undue strain on the frame of the tail or on the rudder may spring these parts out of line and be destructive of accuracy. Great care must therefore be exercised, in slueing the torpedo, not to use excessive force and to apply such force as may be necessary preferably by the nose line hooked in the exercise nose and the tail line hooked or hitched either to the propeller lock or around the propeller nuts close to the hubs.
. Why is the propeller lock habitually kept on the propellers?	The propeller lock is habitually to be kept shipped on the after propeller blade and brought in contact with the forward propeller blade whenever the torpedo is out of the tube, whether the air flask be charged or not, and at all times prior to closing the door of the tube before launching. Instances have occurred when the air in an uncharged flask has been so expanded by rise in temperature as to give sufficient pressure to turn the propellers. The precaution of shipping the propeller lock not only insures against injury to the person should the propellers be accidentally revolved, but furnishes a ready means for attaching and using the tail line at any time.

ASSEMBLING TEST—Continued.

GENERAL REMARKS—Continued.

Question.	Answer.
513. What precautions should be taken when sending torpedoes through hatches?	Torpedoes must not, except when absolutely unavoidable, be sent through the hatches with the air flask charged. The shock of a fall might produce a serious explosion.
514. What care is taken of torpedoes after firing practice?	After finishing a firing practice, if the torpedo i stowed with the intention of resuming the prac tice on the following day, or within a few imme diate subsequent days, not exceeding one week the following care is necessary: To blow th water out thoroughly from the engine, by allow ing the engine to run slowly in the air with th water tripper raised, until no water comes out o the shaft, being sure that the engine oil cup con tains sufficient oil to leave the engine well lubri cated; to drain the immersion chamber and after body; to wipe dry the outside of the shell an to oil it, if stowed under cover, and protecte from moisture, or to coat it with vaseline, i exposed to the weather or dampness, or if stowe in a launching tube; to dry and oil the join screws of the head, the engine-room door screws the drain plugs, the inner surfaces of the vertica vanes, of the rudder connections, and of th guides for the rudder connections; to release th compression of the depth-index and regulato springs; and to release the tension of the releas ing-lever spring. In freezing weather the wate ballast must be emptied from the exercise head A tag should be attached to the torpedo notin the fact that the flask contains air and statin the pressure thereof. Under all other conditions of laying the torped aside after firing practice, in addition to the pre cautions above prescribed, empty the wate ballast from the exercise head; dry the interio of the head thoroughly and touch up with pain if needed; close the stop valve; disconnect th after-body; wipe dry all accessible parts and oi working parts; touch up the inside of the shel with paint where necessary; open the stop valv and let all air out of the air flask; reassemble th torpedo, *leaving air-joint screws slack to avoid mak ing and breaking the joints too often;* and remov all drain plugs to allow circulation of air in th immersion chamber and after-body. Air may be let out of the air flask, on occasion when it is not desired to disconnect the afte body, by slacking up the air-joint screws con necting the air pipe from the air flask to the valv group. Great care must be taken that any water whic may, through negligence, be carried over by th

ASSEMBLING TEST—Continued.

GENERAL REMARKS—Continued.

Question.	Answer.
	air charge is not allowed to collect and stand in the air flask. To this end, while the after-body and head are disconnected, as above, if there be any air pressure in the flask, remove the charging valve and check valve, secure the pendulum by the transportation screw, suspend the flask in a suitable inverted position, open the stop valve, and blow any water that may be in the flask out through the body of the charging valve. If there should be no air pressure in the flask, remove the stop valve, suspend the flask as before, and allow any water present in the flask to drain out through the body of the charging and stop valves. Torpedoes stowed in launching tubes must be carefully examined at least once each week, and especially for signs of tendency to rust at the point where the packing band comes in contact with the shell of the torpedo.
What must be done with torpedoes stowed in brackets or launching tubes?	Torpedoes stowed in brackets must be inspected with sufficient frequency to detect any signs of tendency to rust and to see that they are well protected with oil or vaseline. The engines must be turned by hand at each inspection. Whether torpedoes are stowed in launching tubes or in brackets, the reducing valve, controlling valve, and steering engine valve must be examined, wiped dry, and given a light coat of oil at least once in six months, if the torpedo is not in use, and at the same time the stop valve, charging valve, depth index, and all exterior steel screws must be turned to keep them from setting. Propeller locks must be kept on at all times when torpedoes are stowed, *and if stowed in brackets the pendulums must be secured by the transportation screws.* When carried in tubes, as on torpedo boats, the tube must be kept fore and aft and the tail of the torpedo must rest on the support to be used for that purpose. In transporting torpedoes about the ship, and especially in sending them through hatches, the pendulums must be secured in the same manner and the propeller locks kept on. In preparing for firing practice after a torpedo has remained for some time unused, care must be taken to see that all drain plugs are replaced securely, and it is advisable to balance the rudder to see that the steering engine works properly.

ASSEMBLING TEST—Continued.

GENERAL REMARKS—Continued.

Question.	Answer.
516. What repairs can usually be made on board ship? How can they be done?	The following repairs can generally be made (board ship without the necessity of having r course to a machine shop: Breaks of small par in the mechanism of the torpedo and accessorie dents in the shell of the torpedo; water leaks; a leaks; leaks in valves, and breaks or cracks air pipes. A supply of spare parts to replace such parts of tl mechanism as are most likely to be lost, or broke in exercise, is furnished with each outfit. Shou damage be sustained in parts not covered by th reserve supply recourse must be had, in makir repairs, to tools and material available on boar dimensions being carefully taken from the wor ing drawings. Denting the shell of the torpedo is to be careful guarded against, but when it unavoidably occu the dents may be beaten out from outside tl shell with a wooden mallet or copper hamm against a hard-wood block shaped to conform t the inner surface of the part under treatmen Should a steel hammer be used care must b taken not to bruise the shell. Water leaks of any consequence are unusual, an may occur by reason of the drain plugs not bein screwed in tight; or, after considerable use, b the brazing coming loose between joint rings an shell of the torpedo; or, rarely, by imperfe closure of the diaphragm of the hydrostatic pisto or of the rubber washers of the immersion-cham ber bulkhead, engine bed plate, and tube flang or, still more rarely, through holes in the she due to lack of care in preventing rust, inside (out, or caused by rough handling, or by acc dental injuries incidental to service. A small hole in the shell may be stopped by a stee rivet well soldered after it is clinched. A larg hole, or a cluster of small holes, is best stopped b riveting over them, on the inside of the shell, thin piece of tough sheet steel, shaped to con form to the curve of the shell, sweating on th steel plate, soldering the rivets after they hav been clinched, and soldering the holes from th outside even with the surface. The rivet hole should, in both methods, be beveled from th outside, so that the rivets may have a firm hol sufficient to resist the impulse pressure when th torpedo is launched. Use as small weight of material as possible in mak ing repairs and be careful not to shift the ballas from its original position.

ASSEMBLING TEST—Continued.

GENERAL REMARKS—Continued.

Question.	Answer.
	Air leaks may be detected, when the torpedo is in the water, by bubbles rising to the surface and, when in the open air, by hearing or by touch. If they are in parts difficult of access, they may generally be found by the employment of a lighted taper. When they are very small and difficult of location, a thin layer of oil over the part under examination will entangle the escaping bubbles and determine the exact position of the leak. This last method is particularly applicable to such parts as the exterior angles between the shell of the air flask and its heads, the junction of the body of the charging and stop valves with the head of the air flask, stop valves of air compressors and accumulators whose stems stand vertical, and porous castings. An air leak in the immersion chamber will be indicated by the distention of the diaphragm of the hydrostatic piston. A distention of the diaphragm may be caused by expansion of air in the immersion chamber, due to rise in temperature, but this can be distinguished from the same effect produced by an air leak by the fact that the distention will be much less, and that, the pressure being relieved by removing a drain plug, the distention will not occur again when the drain plug is replaced. Air leaks in the charging valve and stop valve and from the valve-group oil cup may be neglected, provided they are very small, and a small leak around the stem of the controlling valve, when air is admitted to the reducing valve, is unavoidable, but all other air leaks must be carefully attended to. Small air leaks in porous castings can usually be remedied by compressing the metal by hammering, or by a drop of solder. Air leaks in the exterior angle between the shell of the air flask and its heads at the junction of the body of the charging and stop valves with the head, and at the permanent joint of the air pipe where it passes through the joint ring of the immersion chamber may sometimes, if very small, be stopped by solder, the surface having first been carefully cleaned. Experience has shown, however, that there is rarely any remedy for a leak around the head of the air flask, however slight, short of a new head. Air leaks in connections of air pipes indicate that the nuts of the connections are not screwed down sufficiently tight; or, in connections made by

ASSEMBLING TEST—Continued.

GENERAL REMARKS—Continued.

Question.	Answer.
	air-joint screws, that the screws are either n screwed in hard enough; or that they are not s up equally on each side and are, consequentl canting the connections; or that the knife-ed of the joint, or the seat of the knife edge, is d formed. Air leaks around valves under which washers a used may be due to injury to the washer or deformation of the valve. In the latter case tl valve must be reground. Valves which deper for their tightness on a close fit in their seat without the interposition of washers, must l ground in afresh when leaks are developed. Before grinding valves make sure that the lea are not caused by the want of perfect cleanline and, where grinding is necessary, use either alone, or oil and soft oilstone, powdered ar free from grit, or oil and finely ground glas Never use emery dust for this purpose, as it likely to become imbedded in the face of tl valve and there is danger of remaining loo particles being carried by the air into the redu ing and other valves. Breaks and cracks in copper air pipes are not like to occur, but when repairs become necessar due to this cause, cut out the damaged porti and replace it by a length of larger pipe slipp over the cut ends, letting it lap the ends at lea 2 inches and brazing the laps carefully with s spelter, filing down the ends of the larger pie for a smooth finish. An air pipe may be lengt ened in a similar manner by butting against end the lengthening piece and making the jur tion air-tight by slipping over it a sleeve of larg pipe well brazed with soft spelter. In operations involving the bending of copper pipes into S or other curves the pipe must well annealed, by being heated to a cherry r and plunged into cold water, and then gent bent around pattern blocks scored out arou the edges to fit the diameter of the pipe a fastened in place on the workbench. It is c tomary to fill pipes with resin before bendir but, by exercising due care, thoroughly anneal pipes may be bent in this manner without fl tening, even when resin is not employed.

CHAPTER V.

OTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES.

QUESTION.	ANSWER.
17. Give the successive steps in disassembling and assembling the exercise head and the numbers of the tools used.	DISASSEMBLING. 1. Put in steadying pin. Tool used, No. 20. 2. Take out joint screws, beginning with the lower ones and steadying the head meanwhile. Tool used, No. 5. (A wooden carrier made of a barrel stave fashioned with a handle at each end is useful in handling the head and after-body.) 3. Take out steadying pin and remove the head from the air flask. 4. Support the head, nose down, being careful not to dent the shell, and unscrew bulkhead nuts. Tool used, No. 2. 5. Lift off the bulkhead. Tool used, No. 30. ASSEMBLING. 1. Support the head, nose down, being careful not to dent the shell. 2. See that the rubber washer is coated with graphite and in place and replace the bulkhead, setting up on the nuts with equal force in succession. Tool used, No. 2. 3. Ship the head on the air flask and put in steadying pin. Tool used, No. 20. 4. Put in joint screws, beginning with the upper ones, and set them up in succession. Tool used, No. 5. 5. Take out steadying pin.
18. Give the successive steps in disassembling and assembling the stop valve and the numbers of the tools used.	DISASSEMBLING. 1. Unscrew the stop-valve plug. Tools used, Nos. 8 or 18, 19, and 23. 2. Unscrew the stop-valve carrier. Tools used, Nos. 8 or 18 and 25.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

QUESTION.	ANSWER.
	ASSEMBLING. 1. See that the stem of the stop valve revolves freely in the carrier and screw down the carrier. Tools used, Nos. 8 or 18 and 25. 2. See that the washer between the follower and the collar of the operating spindle and the washer under the head of the stop-valve plug are in good condition and in place (tools Nos. 14 and 28) and screw down the stop-valve plug, easing operating spindle as required. Ease the stop valve in its seat after assembling. Tools used, Nos. 8 or 18, 19, and 33.
519. Give the successive steps in disassembling and assembling the charging valve and the numbers of the tools used.	DISASSEMBLING. 1. Screw down the stop valve and unscrew the charging-valve plug. Tool used, No. 19. 2. Unscrew the charging-valve seat. Tool used, No. 19. 3. Lift out the check valve and check-valve spring. Tool used, No. 6. ASSEMBLING. 1. Drop in the check-valve spring and put in the check valve. 2. See that the washer under the shoulder of charging-valve seat is in good condition and in place and screw down the charging-valve seat. Tool used, No. 19. 3. See that the stem of charging valve revolves freely in charging-valve plug and that the washer under charging valve is in good condition and in place; screw down charging valve plug and open stop valve. Tool used, No. 19.
520. Give the successive steps in disassembling and assembling the depth index and the numbers of the tools used.	DISASSEMBLING. N. B.—Depth indexes are not interchangeable. 1. Loosen the clamp nut and set the depth index as indicating 5 feet immersion. Tool used, No. 37. 2. Unscrew the gland of depth index. Tool used, No. 28. 3. Lift out the index sleeve by turning the clamp nut to the right. Tool used, No. 37. 4. Lift out the spindle and inner gear, noting approximate position of eccentric. Tool used, No. 37.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	ASSEMBLING. 1. See that the washer under the shoulder of spindle is in good condition and in place, and put in spindle and inner gear as near as possible in position from which removed. Tool used, No. 37. 2. Turn the clamp nut of index sleeve down to place and put in the index sleeve and inner gear with the mark 5 on the index sleeve coinciding with the fore-and-aft mark on the shell of torpedo. Tool used, No. 37. 3. Screw on the gland of depth index. Tool used, No. 28. 4. Turn back the index sleeve to relieve compression of immersion spring and clamp the index sleeve by turning the clamp nut to the right. Tool used, No. 37.
21. Give the successive steps in disassembling and assembling the valve group and the numbers of the tools used.	DISASSEMBLING. The valve group may be removed without unshipping the after body. 1. Close stop valve and take off engine-room door. Tools used, Nos. 19 and 14. 2. Disconnect the air pipes from valve group to engine and to air flask. Tools used, No. 4, Mark I; No. 19, Mark II. 3. Take out valve-group holding screw. Tools used, No. 5, Mark I; No. 19, Mark II. 4. Lift out the valve group, by hand or with tool. No. 34. ASSEMBLING. 1. Replace valve group, seeing pawls for counter engaged with counter ratchet, by hand or with tool. Tool used, No. 34. 2. Screw in valve-group holding screw. Tools used, No. 5, Mark I; No. 19, Mark II. 3. Connect air pipes from valve group to engine and to air flask, setting up equally on both air joint screws, and open stop valve. Tools used, No. 4, Mark I; No. 19, Mark II. 4. Screw on engine-room door, seeing that the pin on lower arm of bell crank of retarding gear is shipped in the fork of retarding lever. Tool used, No. 14.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
522. Give the successive steps in disassembling and assembling the reducing valve and the numbers of the tools used.	DISASSEMBLING. 1. Close stop valve, throw back starting lever to blow remaining air out of engine, and take off engine-room door. Tools used, Nos. 19 and 14. 2. Unscrew follower of reducing valve cover and take off cover. Tools used, Nos. 8 or 18 and 32. 3. Lift out reducing valve. Tool used, No. 31. 4. Unscrew plug of reducing valve. Tools used, Nos. 16 and 1. 5. Drift out lock pin of piston and unscrew piston from lower end of controlling valve, being careful not to mar the surface. Tool used, No. 24. 6. Take out controlling valve. ASSEMBLING. 1. See all parts perfectly clean and oiled and replace controlling valve. 2. Screw piston on lower end of controlling valve and put in lock pin of piston. 3. See that the washer under the head of reducing valve plug is in good condition and in place and screw in the plug, using monkey wrench with screw-driver to screw the plug in hard, to prevent jarring out. Tools used, Nos. 1 and 16. 4. Replace reducing valve. 5. Replace reducing valve cover and screw on the follower. 6. Put on engine-room door and open stop valve. Tools used, Nos. 8 or 18 and 32.
523. Give the successive steps in disassembling and assembling the regulator and the numbers of the tools used.	DISASSEMBLING. N. B.—Regulator springs are not interchangeable. 1. Unscrew regulator plug. Tool used, No. 37. 2. Take out regulator spring and spring barrel. Tool used, No. 6. ASSEMBLING. 1. Put in regulator spring barrel and spring. 2. Screw in regulator plug, leaving its upper surface flush with upper end of regulator body, to avoid compression of the spring. Tool used, No. 37.

OTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II. TORPEDOES—Continued.

Question.	Answer.
24. Give the successive steps in disassembling and assembling the distance and starting gear and the numbers of the tools used.	DISASSEMBLING. 1. Close stop valve, take off engine-room door, and remove valve group. 2. Take out split pins of counter ratchet and of bell crank. Tool used, No. 7. 3. Take off after-bearing of counter spindle. Tool used, No. 14. 4. Unscrew counter ratchet. 5. Take off bell crank with friction roll and worm-wheel and balance lever. 6. Take out lock pin of friction cam. Tool used, No. 7. 7. Unhook return spring from its stud, take off friction cam and distance-gear sector, and lift off starting lever. ASSEMBLING. 1. Replace starting lever, distance-gear sector, and friction cam, and hook return spring to its stud. 2. Put in lock pin of friction cam. 3. Replace bell crank with friction roll and worm-wheel and balance lever, with counter spindle shipped and counter ratchet ready to screw on. 4. Screw the counter ratchet on. 5. Replace the after-bearing of counter spindle. Tool used, No. 14. 6. Put in split pins of counter ratchet and bell crank. 7. Replace valve group, put on engine-room door, and open stop valve.
25. Give the successive steps in disassembling and assembling the after-body and tail, and the numbers of the tools used.	DISASSEMBLING. N. B.—Propellers are not interchangeable. 1. Close stop valve and take off engine-room door. Tools used, Nos. 9 and 14. 2. Take out connecting screw of steering-engine valve rod. Tool used, No. 10. 3. Disconnect air pipe from valve group to air flask. Tools used, No. 4, Mark I; No. 19, Mark II. 4. Take out joint screws of after-body, beginning with the lower ones, steadying the after-body meanwhile; lift aft and off the after-body. Tool used, No. 5. (A wooden carrier, made of a barrel stave, fashioned with a handle at each end, is useful in handling the head and after-body.)

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.

DISASSEMBLING—continued.

5. Take out connecting screw connecting steering rod with steering-bell crank. Tool used, No. 5.
6. Take out set screws of propeller nuts. Tool used, No. 14.
7. Unscrew tail nut and propeller nuts, beginning aft, using propeller lock to steady the blades as necessary, and using the mallet or a lead hammer to strike the spanner in starting the nuts. When the nuts are all disengaged from the threads slide aft and off the tail with the nuts and propellers. Tools used, Nos. 13, 35, 41, and 42.
8. Take out keys of propeller cones.
9. Unscrew the steering rod from steering-rod union, noting carefully the number of turns required to disengage it, and making a memorandum thereof.
10. Take out keys of tail tube and unscrew tail tube.
11. Take off the friction rings abaft after-gear.
12. Take out gear box oil-cup plug. Tool used, No. 19.
13. Take off after-gear and outer shaft.
14. Take off the friction ring forward of after-gear.
15. Take off crosshead and intermediate gears.
16. Take out set screw of nut of forward gear. Tool used, No. 14.
17. Unscrew nut of forward gear. Tools used, Nos. 12 and 42.
18. Remove forward gear by screwing tool No. 12 on thread of gear and starting it off with the sliding hammer. Tool used, No. 12.
19. Take out keys of forward gear.
20. Disconnect air pipe from valve group to engine; take out valve-group holding screws and lift out valve group. Tools used, Nos. 4, 5, and 34, Mark I; Nos. 19 and 34, Mark II.
21. Disconnect and take out engine oil cup. Tools used, Nos. 5, 14, and 22.
22. Disconnect and take out steering engine, bending admission pipe slightly forward to let it come out clear. Tools used, Nos. 5 and 22.
23. Take out compression spring of steering rod.
24. Take out holding screws of engine body and remove engine and main shaft. Tool used, No. 4.
25. Take off nuts of screw bolts of engine bed plate and screws of tube flange and remove engine bed plate, with shaft tube and steering-rod tube attached. Tools used, Nos. 2 and 30.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	ASSEMBLING. 1. Replace and secure engine bed plate with shaft tube and steering-rod tube attached and secure tube flange, seeing rubber washers under bed plate and under tube flange in good condition, coated with graphite, and in place. Tools used, Nos. 2 and 30. 2. Replace and secure engine body and main shaft. Tool used, No. 4. 3. Put in compression spring of steering rod. 4. Replace and secure steering engine. Tools used, Nos. 5 and 22. 5. Replace and secure engine oil cup. Tools used, Nos. 5, 14, and 22. 6. Replace valve group, screw in holding screw, and connect air pipe from valve group to engine. Tools used, Nos. 4, 5, and 34, Mark I; Nos. 19 and 34, Mark II. 7. Put in keys of forward gear, numbers on keys and numbers on key ways to correspond. 8. Put on forward gear, numbers on gear to correspond with numbers on keys; screw on tool No. 12 and hammer gear home with the sliding hammer. Tool used, No. 12. 9. Screw on nut of forward gear. Tools used, Nos. 12 and 42. 10. Put in set screw of nut of forward gear. Tool used, No. 14. 11. Ship crosshead with intermediate gears. 12. Put on friction ring forward of after-gear. 13. Put on after-gear and outer shaft. 14. Screw in gear box oil-cup plug, seeing washer in good condition and in place. Tool used, No. 19. 15. Put on friction rings abaft after-gear. 16. See that key ways 1, on main shaft, and 3, on outer shaft are in line on top and then screw on tail tube and put in tail-tube keys. 17. Enter steering rod in steering-rod tube from aft and screw it in the steering-rod union a number of turns equal to the number required to unscrew it. See that steering rod is on the right slue for insertion of connecting screw. 18. Put in keys of propeller cones, numbers on keys and numbers of keyways to correspond. 19. Put the tail nut, the propellers, and the propeller nuts in place in the tail, the propeller blades horizontal, with the number on the after-side of after-propeller to starboard and the number on the after-side of forward propeller to port, or in such position that, when

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. B 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	ASSEMBLING—continued.
	the propellers are revolved as for going aheac the numbers will coincide on top. This pre caution is for the purpose of securing coinc dence of the holes for set screws in the pr peller nuts and propeller hubs when the nu are screwed up. Slide on the tail with th propellers and nuts and screw up the nut beginning forward, striking the spanner wi the mallet or with a lead hammer when ne essary. Use the propeller lock to stead blades, and turn the propellers as require either horizontally, as first put on, or vert cally, with numbers on hubs correspondi on top. Tools used, Nos. 13, 35, 41, and 4
	20. Put in set screws of propeller nuts. Tool use No. 14.
	21. Put in connection screw connecting steerir rod with steering-bell crank. Tool use No. 5.
	22. Ship the after-body carefully, seeing the en of counter spindle properly engaged wit ratchet bar of locking gear and put in joi screws of after-body, beginning with th upper ones, steadying the after-body mea while. Tools used, Nos. 5 and 9.
	23. Connect air pipe from valve group to air flas Tools used, No. 4, Mark I, No. 19, Mark I
	24. Put in connecting screw of steering-engi valve rod. Tool used, No. 10.
	25. Put on engine-room door and open stop valv Tools used, Nos. 14 and 19.
	DISASSEMBLING.
526. Give the successive steps in disassembling and assembling the engine and the numbers of the tools used.	The main valves of the engine may be remove for cleaning, or for other purposes, witho disconnecting the after-body, observing su cessive steps 5, 6, and 7 in disassembling th engine and steps 22, 23, and 24 in asser bling.
	1. Place engine body on its after end with ma shaft through a hole in bench.
	2. Take off retarding lever. Tool used, No. 7.
	3. Remove locking strip and screw of crank-ca cover. Tool used, No. 14.
	4. Unscrew crank-case cover. Tools used, Nos. or 18 and 33.
	5. Unscrew valve-chest plugs. Tool used, No. 1
	6. Take out relief valves.
	7. Take out main valves from outer ends of val chests. Tool used, No. 6, or bent wire.
	8. Take out screw of eccentric for counter. To used, No. 14.

OTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	DISASSEMBLING—continued.
	9. Block the crank with a brass rod slipped in and unscrew eccentric for counter, removing eccentric and eccentric strap. Tools used, Nos. 8 or 18 and 32.
	10. Take out cam for valves. Tool used, No. 38.
	11. Take out key of cam for valves.
	12. Remove pawls for counter from ratchet rod. Tool used, No. 7.
	13. Take out ratchet rod of pawls for counter.
	14. Take out set screws of screws holding guide ring for valves. Tool used, No. 14.
	15. Take out screws holding guide ring for valves. Tool used, No. 15.
	16. Remove guide ring for valves.
	17. Remove valve rods and rolls from inner ends of valve chests.
	18. Slip off round bearing.
	19. Unscrew plug for hole for disassembling crank. Tool used, No. 15.
	20. Take out screw of removable piece in crank. Tool used, No. 5.
	21. Take out removable piece in crank.
	22. Remove safety screws from crank-pin brasses. Tool used, No. 14.
	23. Take out screw pins joining connecting rods to crank-pin brasses. Tool used, No. 15.
	24. Slide back pistons, with connecting rods attached, within the cylinders.
	25. Take out crank-pin brasses.
	26. Lift out crank and main shaft.
	27. Take out pistons with connecting rods attached.
	ASSEMBLING.
	Make liberal use of winter strained sperm oil, while assembling, on all bearings and working surfaces.
	1. Place engine body on its after end on bench.
	2. Put pistons with connecting rods attached, each within its own cylinder, as indicated by Nos. 1, 2, and 3. Tool used, No. 39.
	3. Put in main shaft and crank.
	4. Ship crank-pin brass No. 1, connect it by screw pin with connecting rod No. 1, replace safety screw in crank-pin brass and set lock pin of screw pin back in contact with safety screw. Tools used, Nos. 14 and 15.
	5. Ship crank-pin brass No. 2, connecting it with connecting rod No. 2. Tools used, Nos. 14 and 15.
	6. Ship crank-pin brass No. 3, connecting it with connecting rod No. 3. Tools used, Nos. 14 and 15.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	ASSEMBLING—continued. 7. Replace removable piece in crank. 8. Replace screw of removable piece in crank. Tool used, No. 5. 9. Replace plug for hole for disassembling crank, seeing that its washer is in good conditio and in place. Tool used, No. 15. 10. Slip on round bearing. 11. Replace valve rods and rolls Nos. 1, 2, and 3 each in its own valve chest, entering ther from inner ends of valve chests. 12. Replace guide ring for valves Nos. 1, 2, and on guide ring and on forward face of cran case corresponding. 13. Put in screws holding guide ring for valves Tool used, No. 15. 14. Replace set screws of screws holding guide rin for valves. Tool used, No. 14. 15. Replace ratchet rod of pawls for counter. 16. Pin pawls for counter to ratchet rod, bein careful that the pawls work in right direc tion. 17. Put in key of cam for valves. 18. Slip on cam for valves, setting it home with brass rod and hammer. Tool used, No. 11 19. Put in eccentric strap and connect it with ratchet rod. 20. Screw on eccentric for counter, locking th crank with a brass rod. Tools used, Nos. or 18 and 32. 21. Put in screw of eccentric for counter. Too used, No. 14. 22. Replace main valves from outer ends of valv chests. 23. Replace relief valves. 24. Replace valve-chest plugs, seeing that thei washers are in good condition and in place Tool used, No. 19. 25. Screw on crank-case cover. Tools used, Nos 8 or 18 and 33. 26. Replace locking strip and screw. Tool used No. 14. 27. Replace retarding lever. Tool used, No. 7.
527. Give the successive steps in disassembling and assembling the immersion chamber and the numbers of the tools used.	DISASSEMBLING. N. B.—Do not change adjustment of checkin springs of pendulum except by special orde of the torpedo officer. 1. Close stop valve, and take off the after-body, ob serving successive steps 2, 3, and 4 in note on disassembling after-body and tail. 2. Disassemble the depth index, observing succes sive steps in notes on disassembling depth index.

OTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	DISASSEMBLING—continued. 3. Unscrew nuts holding bulkhead of immersion chamber. Tool used, No. 2. 4. Remove bulkhead of immersion chamber. Tool used, No. 30. ASSEMBLING. 1. See that the after-edge of the shoulder of the forward spring box in the tube containing the immersion spring coincides with the line marked 5 on the side of the tube and replace bulkhead of immersion chamber, with its rubber washer in good condition, coated with graphite and in place. Tool used, No. 30. 2. Screw on nuts holding bulkhead of immersion chamber, setting up in succession with equal force. Tool used, No. 2. 3. Assemble the depth index, observing successive steps in notes on assembling depth index. 4. Ship the after-body, observing successive steps 21, 22, and 23 in notes on assembling after-body and tail, and open stop valve.
28. Give the successive steps in disassembling and assembling the hydrostatic piston and the numbers of the tools used.	DISASSEMBLING. N. B.—Immersion springs are not interchangeable. 1. Unscrew the nuts of ring for diaphragm and take off the ring. Tools used, No. 3, Mark I; No. 2, Mark II. 2. Take off the diaphragm. 3. Take out split pins and pins of hydrostatic piston lever and of lever fork and remove hydrostatic piston lever and diaphragm plate. Tool used, No. 7. 4. Unscrew the lugs of forward spring box. Tool used, No. 16. 5. Take out forward spring box, immersion spring, and after spring box. ASSEMBLING. 1. Replace after spring box, immersion spring, and forward spring box. 2. Screw in the lugs of forward spring box. Tool used, No. 16. 3. Replace diaphragm plate and hydrostatic piston lever and put in pins and split pins of hydrostatic piston lever and of lever fork. Tool used, No. 7. 4. Replace diaphragm, seeing it in good condition and coated with graphite. 5. Replace ring for diaphragm and secure it, setting up on nuts in succession with equal force. Tools used, No. 3, Mark I; No. 2, Mark II.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

QUESTION.	ANSWER.
529. Give the successive steps in disassembling and assembling the connecting rods and sleeves and the numbers of the tools used.	DISASSEMBLING. 1. Take out split pin and pin of lever fork and splii pins of cross-lever pin and of rock-lever pin Tool used, No. 7. 2. Take off cross lever and connecting rods anc sleeves. 3. Unscrew gland of sleeve and take out connectin rod. Tool used, No. 28. 4. (If necessary) Drift out lock pin of nut of con necting rod, unscrew the nut, and remove spring. ASSEMBLING. 1. Slip the spring over connecting rod, screw on the nut, and put in lock pin. 2. Slip the connecting rod in the sleeve and screw on the gland. Tool used, No. 28. 3. Replace the cross lever and connecting rods anc sleeves. 4. Put in pin and split pin of lever fork and spli pins of cross-lever pin and rock-lever pin Tool used, No. 7.
530. Give the successive steps in disassembling and assembling the stuffing box and the numbers of the tools used.	DISASSEMBLING. 1. Take out split pin of rock-lever pin and unshi lower connecting sleeve from rock-lever pin Tool used, No. 7. 2. Take out stuffing-box plug. Tool used, No. 15 3. Unscrew set screw of inside rock lever. Too used, No. 14. 4. Draw out rock shaft with outside rock leve attached. 5. Take out inside rock lever, with locking jaw and connection of locking jaws to inside roc lever attached. 6. (If necessary) Take out screws holding stuffin box to bulkhead and take off stuffing box Tool used, No. 14. ASSEMBLING. 1. Secure stuffing box to bulkhead, seeing that th washer of oiled paper under its base is i good condition and in place. Tool used, No 14. 2. Replace inside rock lever, with locking jaws an connections of locking jaws to inside roc lever attached. 3. Replace rock shaft, with inside rock lever at tached. 4. Put in set screw of inside rock lever. Tool used No. 14.

OTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.

ASSEMBLING—continued.

5. Screw in stuffing-box plug, seeing that its washer is in good condition and in place. Tool used, No. 15.
6. Ship lower connecting sleeve on rock-lever pin and put in split pin. Tool used, No. 7.

1. Give the successive steps in disassembling and assembling the pendulum and the numbers of the tools used.

DISASSEMBLING.

N. B.—When disassembling the pendulum do not change the adjustment of the checking springs.

1. Take out split pin of cross lever and slip off cross lever. Tool used, No. 7.
2. Take out split pin and pin of hinge of checking-spring rod. Tool used, No. 7.
3. Drift out lock pin securing forked bell crank to pendulum-rod pin. Tools used, Nos. 11 and 24.
4. Drift out pendulum-rod pin. Tools used, Nos. 11 and 24.

The pendulum bob may be removed from the pendulum rods by unscrewing the nuts of pendulum rods on under side of the bob.

The pendulum buffers may be removed by taking out set screws of stop plugs (tool No. 14), and unscrewing the stop plugs (tool No. 34).

ASSEMBLING.

1. Hang the pendulum rods to pendulum supports by the pendulum-rod pin. Tool used, No. 11.
2. Put in lock pin securing forked bell crank to pendulum-rod pin. Tool used, No. 11.
3. Connect hinge of checking-spring rod to hinge eye, putting in pin and split pin. Tool used, No. 7.
4. Replace cross lever and put in split pin. Tool used, No. 7.

2. Give the successive steps in disassembling and assembling the engine oil cap and the numbers of the tools used.

DISASSEMBLING.

1. Take out screws connecting oil pipe to socket in crank-case cover. Tool used, No. 14.
2. Disconnect air pipe from the nipple on air passage of starboard upper valve chest. Tool used, No. 22.
3. Take out screws holding filling pipe to shell of torpedo. Tool used, No. 14.
4. Unscrew holding screws. Tool used, No. 5.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	ASSEMBLING. 1. Secure oil cup to engine-room cage with holding screws. Tool used, No. 5. 2. Secure filling pipe to shell of torpedo. Tool used, No. 14. 3. Connect air pipe to nipple on air passage of starboard upper valve chest. Tool used, No. 22. 4. Connect oil pipe to socket in crank-case cover, seeing that the washer under it is in good condition and in place. Tool used, No. 14.
533. Give the successive steps in disassembling and assembling the steering engine and the numbers of the tools used.	N. B.—In disassembling the steering engine do not change the adjustment of the valve star, except by special order of the torpedo officer, noting carefully, in case the adjustment is changed, the number of turns and fractions of turns required to unscrew the union for the valve rod that it may be reassembled in its original position. DISASSEMBLING (MARK I). Note.—It will generally be found necessary, in completely disassembling the steering engine, Mark I, torpedoes to disassemble the after-body and tail. The steering engine may sometimes, however, be removed without disassembling the after-body and tail by observing the successive steps in the following table, but it is a difficult operation which can not always be successfully performed. The valve alone may be easily removed for cleaning or for inspection. 1. Put rudder up to bring piston of steering engine to forward end of throw. 2. Unscrew limiting plug. Tool used, No. 27. 3. Remove valve. *If necessary to remove piston.* 4. Disconnect admission and exhaust pipes from nipples on engine body. Tool used, No. 22. 5. Slack up gland of stuffing box in head and unscrew cylinder head, being particularly careful not to bruise or scratch stem of piston by slipping of the tool. Tools used, Nos. 28 and 23 or 7. 6. Unscrew piston from steering-rod union, using tool No. 23 inserted in end of air channel, noting the number of turns required to unscrew it and making a memorandum thereof. Tool used, No. 23.

[NO]TES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	DISASSEMBLING (MARK I)—continued. *If necessary to remove piston*—Continued. 7. Take out holding screws and remove steering engine. Tool used, No. 5. 8. Slack up gland of stuffing box in back head and remove piston. Tool used, No. 28. 9. Unscrew glands of stuffing boxes in head and in back head. Tool used, No. 28. ASSEMBLING (MARK I). 1. See gaskets of stuffing boxes in head and in back head in good condition and in place, and screws in glands slack. Tool used, No. 28. 2. Insert piston in cylinder. Tool used, No. 26. 3. Set up gland in stuffing box in back head. Tool used, No. 28. 4. See that compression spring of steering rod is in place, replace steering engine, and put in holding screws. Tool used, No. 5. 5. Screw after-stem of piston in steering-rod union a number of turns equal to the number required to unscrew it, using tool No. 23 inserted in end of air channel in piston. Tool used, No. 23. 6. Screw in cylinder head, seeing that its washer is in good condition and in place, taking care not to bruise or scratch stem of piston by slipping of the tool. Tool used, No. 23 or 7. 7. Set up gland of stuffing box in head. Tool used, No. 28. 8. Replace valve, seeing that it is perfectly clean. 9. Screw in limiting plug. Tool used, No. 27. DISASSEMBLING (MARK II). 1. Take out connecting screw connecting steering rod with steering bell crank. Tool used, No. 5. 2. Disconnect admission and exhaust pipes from nipples on engine body. Tool used, No. 22. 3. Take out holding screws and draw out steering engine with steering rod attached. Tool used, No. 5. 4. Unscrew steering-rod union from after-stem of piston, noting the number of turns required to unscrew it and making a memorandum thereof. 5. Unscrew limiting plug and take out valve. Tool used, No. 27 or 28. 6. Slack up glands of stuffing boxes in head and in back head. Tool used, No. 28.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. B 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	DISASSEMBLING (MARK II)—continued. 7. Unscrew cylinder head. Tool used, No. 23. 8. Remove piston. 9. Unscrew glands of stuffing boxes in head ai in back head. Tool used, No. 28. ASSEMBLING (MARK II). 1. See gaskets of stuffing boxes in head and back head in good condition and in plac and screw in glands slack. Tool used, N 28. 2. Insert piston in cylinder. Tool used, No. 26 3. Screw on cylinder head, seeing that its wash is in good condition and in place. To used, No. 23. 4. Set up glands of stuffing boxes in head and back head. Tool used, No. 28. 5. Insert valve and screw in limiting plug. To used, No. 27 or 28. 6. Screw steering-rod union on after stem of pi ton a number of turns equal to the nur ber required to unscrew it. 7. Replace steering engine with steering rod a tached and put in holding screws. To used, No. 5. 8. Connect admission and exhaust pipes to ni ples on engine body. Tool used, No. 22. 9. Replace connecting screw connecting steerir rod with steering-bell crank. Tool use No. 5.
534. Give the successive steps in disassembling and assembling the depth register and the numbers of the tools used?	DISASSEMBLING. (Use tools supplied in depth and rolling register box.) *Piston.* 1. Unship after-section of outer tube. (Righ handed bayonet joint.) 2. Unship the base-carrying drums for pape (Left-handed bayonet joint.) 3. Unscrew the extension sleeve, being caref not to bend spring pencil in handling. 4. Slip off forward section of outer tube. 5. Take out set screw of conoidal head and ui screw the head. 6. Unscrew nut from forward end of spiral spring. 7. Draw out piston with spring attached.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	DISASSEMBLING—continued.
	Gears in forward end.
	8. Take out screws holding bracket of gear and pinion, remove bracket and take out gear and pinion.
	9. Take out locking screw of forward gear of compound spindle gear and slip off the gear.
	10. Unscrew and remove glands of stuffing box of spindle of compound spindle gear and remove spindle with its after-gear attached.
	Screw fan.
	11. Take out lock pin of check nut on shank of screw fan, unscrew check nut and remove screw fan.
	ASSEMBLING.
	(Use tools supplied in depth and rolling register box.)
	Screw fan.
	1. Replace screw fan, screw on check nut, observing assembling marks, and put in lock pin.
	GEARS IN FORWARD END.
	2. Replace spindle of compound spindle gear, with its after-gear attached, and screw glands of stuffing box of spindle in place, with the gasket in good condition, coated with tallow and black lead, and in place.
	3. Slip on forward gear of the compound spindle gear, seeing that the forward faces of the gear and of the spindle are flush, and screw in the locking screw.
	4. Replace gear and pinion, slip its bracket in place, and secure bracket with screws.
	Piston.
	5. Thoroughly clean the piston and inside of inner tube, do not use anything in cleaning that will wear them down, and oil piston and inside tube with sperm oil. Run the after-nut on forward end of spiral spring clear aft on its thread and replace the spring and piston, observing assembling marks on base of piston and on side of outer tube, that the spring may be in its proper place.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	GEARS IN FORWARD END—continued. *Piston*—Continued. MEMORANDUM.—In case the eye in base of piston for hook of spiral spring, has been removed see that its washer is in good condition and in place before reassembling. 6. Screw on nut of forward end of spiral spring. 7. Screw on conoidal head, observing assembling marks, and put in set screw. 8. Slip on forward section of outer tube. 9. Screw on extension sleeve. 10. Ship base-carrying drums for paper. 11. Ship after-section of outer tube, observing assembling marks at the joint.
535. Give the successive steps in disassembling and assembling the rolling register and the numbers of the tools used.	DISASSEMBLING. (Use tools supplied in depth and rolling register box.) 1. Remove cap at after-end of tube. 2. Disengage sectional nut from shaft of screw fan and slide out the pendulum, being careful not to bend the spring pencil. 3. Take out set screw of conoidal head and unscrew conoidal head. 4. Take out screw plug from side of extension sleeve, turn extension sleeve until the lock screw through forward end of tube and after end of adjusting collar comes in sight through the hole for the screw plug, and unscrew the lock screw. 5. Unscrew tube from adjusting collar, using wooden clamps if necessary. 6. Slip off extension sleeve. *To remove axial shaft.* 7. Take out screws holding bracket of side gear remove bracket and take out side gear. 8. Unscrew gland of stuffing box of shaft and draw out shaft. *To remove screw fan.* 9. Take out lock pin of check nut on shank of screw fan, unscrew check nut, and remove screw fan.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M. BY 45CM., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	ASSEMBLING. (Use tools supplied in depth and rolling register box.) 1. Replace screw fan, screw on check nut, observing assembling marks, and put in lock pin. 2. Ship axial shaft in adjusting collar and set up gland of stuffing box. 3. Replace side gear, ship its bracket in place and secure bracket with screws. 4. See that the porpoise-hide washer on after-end of adjusting collar is in place and well oiled, and that it is of even thickness, to prevent leaking when set up, and that it is thick enough to bind the adjusting collar against the extension sleeve with sufficient firmness to prevent the former from turning during run of torpedo, and slip on the extension sleeve. 5. Screw the tube in the adjusting collar, using wooden clamps, setting it up until the extension sleeve is forced firmly against the washer, and until the assembling marks, 0 on the upper side of the extension sleeve and adjusting collar and the line cut on the upper side of the tube, come in line. 6. Put in the lock screw through forward end of tube and after-end of adjusting collar and replace screw plug in hole in side of extension sleeve, seeing lead-foil washer under the plug in good condition and in place. 7. Screw on conoidal head, observing assembling marks, and put in set screw. 8. Replace pendulum, stamped arrows pointing forward. MEMORANDUM.—In case the pendulum frame has been disassembled, see that stamped arrows on pendulum and on sleeve of pendulum frame coincide. 9. Ship the cap on after-end of tube.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M., MARK III, AND THE 5M., MARKS I AND II, TORPEDOES.

5. Give the successive steps in disassembling and assembling the depth index and the numbers of tools used.	DISASSEMBLING. 1. Unscrew the lock nut over the spindle and set for 5 feet immersion. Tool used, No. 37. 2. Lift out spindle and worm. Tool used, No. 30. 3. Unscrew clamp nut over worm wheel. Tool used, No. 47. 4. Take out worm wheel and ring. Tool used, No. 6.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M., MAR III, AND THE 5M., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	ASSEMBLING. 1. Put in worm wheel and ring, seeing that t slot in the ring is directly over the st projecting inside the depth-index body. 2. Screw in the clamp nut over the worm whe and turn the latter so that the graduati 10 shows through the hole in the clamp nu Tool used, No. 47. 3. See that the washer under the shoulder of t spindle is in good condition and in pla and put in the spindle and worm as n as possible in the position from which moved. When down in place, the figur should show through the central hole in t clamp nut. 4. Screw down the lock nut over the spind Tool used, No. 37.
537. Give the successive steps in disassembling the after-body and tail and the numbers of the tools used.	DISASSEMBLING. 1. If not out, remove the gyro gear or weig 2. Close stop valve and take off engine-ro door. Tools used, Nos. 19 and 14. 3. Take out connecting screw of steering-eng valve rod. Tool used, No. 10. 4. Disconnect air pipe from valve group to flask. Tools used, Nos. 4 or 19 and 49. 5. Take out joint screws of after-body, beginn with the lower ones, steadying the aft body meanwhile; lift off the after-bo Tool used, No. 5. 6. Take out connecting screw connecting steer rod of vertical rudders with yoke and sc it in yoke. Tool used, No. 5. 7. Take out connecting screw connecting steer rod of horizontal rudders with steering-l crank. Tool used, No. 5. 8. Take out set screws of propeller nuts. T used, No. 14. 9. Put on propeller lock. Start propeller n slightly, using mallet or lead hammer a spanner if necessary. Tools used, Nos. 35, 41, and 42. 10. Take out joint screws of tail; take screw ou f rudder spindle yoke; turn horizontal rud r steering rod one-fourth turn to the left, t the tail aft and off. Tool used, No. 5. 11. Take out gear-box oil-cup plugs. Tool us No. 19 or 4. 12. Unscrew alternately after and forward p peller nuts, which will force the shafts d crosshead forward until free, when rem e them. Remove propellers and cones. n the 5m., Mark II, unscrew the after prope r

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M., MARK II, AND THE 5M., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	DISASSEMBLING—continued.
	nut entirely first and then the forward propeller nut, removing the gears, shafts, etc. Tools used, Nos. 41 and 42.
	13. Unscrew the steering rod from steering-rod union, counting and noting turns.
	14. Unscrew rudder connection to steering rod of gyro, counting and noting turns.
	15. Take out pin connecting steering rod to engine connection of gyro and remove steering rod through gyro door.
	16. Take out keys of outer shaft and remove its sleeve bearing. Tool used, No. 14.
	17. Take off friction rings abaft after gear.
	18. Take out keys of inner shaft and remove its sleeve bearing. Tool used, No. 14.
	19. Remove crosshead, intermediate gears, and friction rings on each side of crosshead.
	20. Remove vertical rudders. Tool used, No. 14.
	21. Disconnect air pipe from valve group to engine and gyro gear. Tools used, Nos. 4 or 19, 22, and 49.
	22. Take out split pin, screw in 5m., Mark II, and disconnect link from push rod of gyro gear. Tool used, No. 14.
	23. Remove rack.
	24. Take out valve-group holding screws and lift out valve group. Tool used, No. 4.
	25. Disconnect and take out engine oil cup. Tools used, Nos. 5, 14, and 22.
	26. Disconnect supply and exhaust pipes to steering engine, disconnect engine and take it out. Tools used, Nos. 5 and 22.
	27. Take out compression spring of steering rod.
	28. Disconnect gyro reducing-valve air pipe from the engine valve chest. Tool used, No. 22.
	29. Take off adjusting-sleeve nut, remove valve spring, release collar in valve lever, and remove reducing-valve rod and lever. Tools used, Nos. 14 and 37.
	30. Take out holding screws of engine body, and remove engine and main shaft. Tools used, Nos. 2 and 4.
	31. Disconnect gyro-gear air pipe from engine-room bulkhead. Tool used, No. 22.
	32. Take off nuts of screw bolts of engine bed plate, and screws of tube flange, and remove engine bed plate, with shaft tube and steering rod attached. Tools used, Nos. 2, 5, and 30.
53. Give the succession steps in disassembling the immersion chamber and the numbers of the tools used.	DISASSEMBLING. Same as 3.55m., Mark I, torpedo, except step 2, for which substitute the following:

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M., MAR III, AND THE 5M., MARKS I AND II, TORPEDOES—Continued.

QUESTION.	ANSWER.
	DISASSEMBLING—continued. 2. Unscrew the lock nut over the spindle of tl depth index; remove the spindle and worr Tools used, Nos. 37 and 30.
539. Give the successive steps in disassembling and assembling the hydrostatic piston and the numbers of the tools used.	DISASSEMBLING. 1. Unscrew the nuts of ring for diaphragm a take off the ring. Tools used, Nos. 2 and 1 2. Take off the diaphragm. 3. Take out split pins and pins of hydrostati piston lever, of lever fork, and at elbow bell crank of testing attachment. Tc used, No. 7. 4. Drop the upper arm of the bell crank, so th the ball on that arm clears the socket in t hydrostatic piston, and remove the hydı static-piston lever and diaphragm plat Tool used, No. 7. 5. Unscrew the lugs of forward spring box. Tc used, No. 16. 6. Take out forward spring box, immersion sprir and after spring box. 7. Lift the adjusting screw out of the socket p to free the upper end of the compositi jew's-harp link and slip it off over the tu for the hydrostatic-piston spring.
540. Give the successive steps in disassembling the steering engine and the numbers of the tools used.	ASSEMBLING. To assemble the hydrostatic piston, reverse t preceding steps. 1. Take out connecting screw connecting t forward valve adjusting bell crank to sh rod from immersion mechanism. Tool us No. 10. 2. Take off the after-body. 3. Take out connecting screw connecting steer rod with steering bell crank in tail. T used, No. 5. 4. Take off tail. Unscrew steering rod from t steering-rod union, counting and noti turns. 5. Disconnect admission and exhaust pipes fr nipples on engine body. Take out hold screws and remove steering engine, lock dial, and rudder index. Tools used, N 5 and 22. 6. Take out split pin and pin to long locking b unscrew locking-ring screws, and rem long locking bar clear of steering engi Tool used, No. 14.

[N]OTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M., MARK III, AND THE 5M., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	ASSEMBLING—continued.
	7. Hold after end of piston rod with clamps and unscrew union.
	8. Unscrew limiting plug, and take out valve. Tool used, No. 27 or 28.
	9. Unscrew front cylinder head. Tool used, No. 23.
	10. Remove piston.
	11. Unscrew glands of stuffing boxes in front and back heads. Tool used, No. 28.
	DISASSEMBLING.
[1]1. Give the successive steps in disassembling and assembling the locking dial and rudder index and the numbers of the tools used.	1. Unscrew lock nut of adjustment cam. Tool used, No. 48.
	2. Unscrew clamp nut, and remove locking-adjustment index, index washer, adjustment-cam sleeve (rudder index), and outer bevel-gear sector. Tool used, No. 48.
	3. Drift out pin, unscrew nut on bolt, and remove lock-sleeve sector, lock sleeve and flange, spring and locking ring. Tools used, Nos. 1 and 24.
	ASSEMBLING.
	1. Put on locking ring, with the jaws of the long arm over the flat part of the steering-engine valve rod.
	2. Put on the lock sleeve, seeing that the pin on the under side of the flange comes in position in the circular score in the locking-bar slide block.
	3. Put on the adjustment cam (rudder index) with the straightedge of the cam in the segmental score of the locking-bar slide block.
	4. Put in the spring (which holds down the lock sleeve), the washer, the lock-sleeve sector, screw on nut and put in pin. Tool used, No. 1.
	5. Put on the outer bevel-gear sector.
	6. Put in the index washer.
	7. Put on the setting bar (locking adjustment index) and screw on its clamp nut. Tool used, No. 48.
	8. Put on the adjustment cam (rudder index) lock nut. Tool used, No. 48.
	9. Screw in the glands of stuffing boxes, slack, in front and back heads of steering engine. Tool used, No. 28.
	10. Insert piston in cylinder.
	11. Screw on cylinder head, seeing that its washer is in place. Tool used, No. 23.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M., MARK III, AND THE 5M., MARKS I AND II, TORPEDOES—Continued.

QUESTION.	ANSWER.
	ASSEMBLING—continued. 12. Set up glands of stuffing boxes in head and in back head. Tool used, No. 28. 13. Insert valve and screw in limiting plug. Tool used, No. 27 or 28. 14. Screw steering-rod union on after-stem of piston. 15. Put in pin through long locking arm and valve rod, put in split pin, and screw in locking-ring screws. 16. Put in steering engine and set up holding screws; connect admission and exhaust pipes. Tools used, Nos. 5 and 22. 17. Screw steering rod in steering-rod union. 18. Put on the tail, being careful to secure coincidence of the assembling marks on the two shaft sections. 19. Put in connecting screw connecting steering rod with steering bell crank, in tail. Tool used, No. 5. 20. Put on the after-body. 21. Put in the connecting screw connecting the forward valve adjusting bell crank to short rod from immersion mechanism.
542. Give the successive steps in disassembling and assembling the valve group of the 5m., Mark II, and the numbers of the tools used.	DISASSEMBLING. 1. Close stop valve and take off engine-room door. Tools used, Nos. 19 and 14. 2. Take out connecting screw of steering-engine valve rod. Tool used, No. 10. 3. Disconnect air pipe from valve group to air flask. Tools used, Nos. 4, 19, and 49. 4. Disconnect after-body. Tool used, No. 5. 5. Remove rack. 6. Take out screw and disconnect link from push rod of gyro gear. Tool used, No. 14. 7. Take out valve-group holding screws and lift out valve group. Tool used, No. 4. 8. Remove push link for gyro-gear connection. 9. Unscrew nut on end of counter spindle, take off worm wheel, and take out counter spindle. Tool used, No. 1. 10. Remove pinion sleeve, spring, and washer against which the after end of the spring bears. 11. Take off bell crank, or pinion-sleeve lever. 12. Remove taper pin from screw pivot, unscrew the pivot and take off water tripper and retarding lever. Tools used, Nos. 7 and 14. 13. Remove toggle connection. Tool used, No. 7. 14. Remove connecting rod and sleeve. Tool used, No. 7.

ES ON DISASSEMBLING AND ASSEMBLING THE 3.55M., MARK I, AND THE 5M., MARKS I AND II, TORPEDOES—Continued.

Question.	Answer.
	DISASSEMBLING—continued. 15. Take off friction rolls and the split collar. Tool used, No. 7. 16. Disconnect the starting link from balance lever and remove balance lever and take out main valve stem. Tool used, No. 7. 17. Disconnect and remove starting lever and link. Tool used, No. 7. 18. Unscrew the fulcrum bracket. Tool used, No. 14. 19. Unscrew gland from bottom of main valve chest and take out kid-leather washer. Tool used, No. 50. 20. Unscrew follower ring in top of main valve chest and take out plug, spiral spring, and main and starting valves. Tool used, No. 19. 21. Take off index pointer. Tool used, No. 7. 22. Remove friction wheel with return spring. 23. Unscrew follower from bottom of distance-gear cylinder and remove distance-gear worm wheel, regulator spring, and distance-index washer. Tool used, No. 51. ASSEMBLING. To assemble the valve group, reverse the preceding steps. Attention must be paid to the correct location of the washers and pins. The main and starting valves, valve stem, and all bearings must be cleaned and oiled.
Give the successive steps in disassembling and assembling the reducing valve of the 5m., Mark II, and the numbers of the tools used.	DISASSEMBLING. The engine must first be removed. Proceed as under disassembling after-body and tail, given above. 1. Unscrew plug from bottom of reducing-valve chest. Tool used, No. 19. 2. Insert tool 37 in top of valve plug and push valve through bottom of chest as far as it will go. Take out pin and unscrew lock nut. Take off valve and push plug out through top of chest. Tools used, Nos. 37 and 52. ASSEMBLING. Reverse preceding steps, clean and oil the valve.
Give the successive steps in disassembling the engine of the 5m., Mark II, and the numbers of the tools used.	The following are the only changes in disassembling the engine of the 5m., Mark II, torpedo: 1. Unscrew plug from bottom of worm-wheel casing and remove intermediate counter spindle. Tool used, No. 19.

NOTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M., MARK III, AND THE 5M., MARKS I AND II, TORPEDOES—Continued.

THE GYRO GEAR.

Question.	Answer.
	ASSEMBLING—continued. 2. Unscrew locking strip, unscrew follower lock ring and take out crank-case cover. Tools used, Nos. 14–53. 3. Take out set screw and unscrew cam-follower ring. Tools used, Nos. 14–54.

THE GYRO GEAR.

545. Give the successive steps in assembling the gyro gear.	1. Clean out the steering-engine cylinder with clean oily waste. 2. Put in cylinder head between steering-engine and air-cushion cylinders and set up tightly, using winding key inserted through steering-engine cylinder. 3. Oil piston and piston rod of steering engine and put them in. 4. See that the packing of the stuffing box of the steering engine is in good order and in place. For packing, use a piece of two-strand lamp wicking, about 9 inches long, dipped in best tallow. Use an oiled linen paper washer under both cylinder heads. 5. Screw the outer cylinder in tightly with flat open-end hexagonal $\frac{17}{32}$-inch wrench. 6. Set up on the stuffing box with thumb nut, so that the piston works moderately tight. 7. Put in split pin holding bonnet of stuffing box from turning. 8. Put in the air-cushion pistons, the one with the screw hole in it being outward. 9. Put the cushion lever on the impulse sector. 10. Put the impulse sector in place, the stop arm in piston of air-cushion cylinder, and insert its shaft to see that they fit properly. 11. Put on the impulse-sector stop. 12. Take out the shaft, and put on the impulse spring. 13. Put in screws holding the ends of the impulse spring. 14. Put sector and spring in place in frame, and put in impulse-sector shaft. 15. Secure ends of spring to screws. 16. See that the impulse-sector stop is on the right side of the stop arm for cushion piston. 17. Screw the outer ring centers in place until they are just through the frame. 18. Secure inner ring in outer one by its centers, balancing it neatly. 19. Put rings in frame and screw in outer-ring centers. 20. Put in the position holder.

OTES ON DISASSEMBLING AND ASSEMBLING THE 3.55M., MARK III, AND THE 5M., MARKS I AND II, TORPEDOES—Continued.

THE GYRO GEAR—Continued.

Question.	Answer.
	21. Put in vertical rock shaft for centering gyroscope wheel. 22. Put gyroscope in ring, balancing it neatly. 23. Insert a block of wood about 1½ inches thick between the impulse sector and frame, to bring the sector into position to mesh with the teeth of the axle of the gyroscope wheel. 24. Turn up the clutch of the position holder by hand until it bears against the inner ring, to get the rings at right angles to each other. Then move the vertical rock shaft bodily up or down as necessary, by means of the screws at its ends, until the centering stud enters the axle of the gyroscope wheel. When in the right position, lock the rock shaft against vertical motion by setting up the locking nuts at the ends of the shaft. 25. Examine the meshing of the impulse sector and teeth on the axle of the gyroscope wheel, to see that it is done satisfactorily, and see that the clutch brings up against the inner ring, to bring it in proper position for the centering stud to enter the socket in the axle of the gyroscope wheel. 26. Put in the clamp screws of the outer-ring centers. 27. Put in the horizontal rock shaft, the double-acting rock-shaft spring and shaft, and the split pin in the end of the shaft. 28. Hook up the auxiliary horizontal rock-shaft spring (a piece of brass wire) and put in split pin. 29. Clean control valve with oily waste and wash it off with a blast of air from the charging pipe. 30. Put in the valve plug, put on the valve arm, holding-down springs, valve guard and nuts. Put in the valve-arm holding screw, seeing that the valve is on the center, with the valve arm in mid position, before setting up the screw tightly. DISASSEMBLING. To disassemble the gyro gear proceed in reverse order.

MINES.

CHAPTER VI.

NAVAL DEFENSE MINE.

THE MINE CASE.

Question.	Answer.
What is the shape of the mine case?	Spherical.
What is its diameter?	32 inches inside.
In how many parts is it made?	In 2, the upper and lower half.
How is each half made?	It is stamped from sheet steel $\frac{3}{16}$-inch thick.
Why is the edge of each half turned up?	To afford a hold for the clamps.
What are the clamps used for?	To secure the 2 halves of the mine case together when the mine is assembled.
What are the 4 supports in the upper half of the mine case for?	To secure a malleable-iron frame for holding the 4 mine charges of wet gun cotton.
How are the mine charges held in this frame?	By 2 machine steel side rods and a malleable-iron clamping bar across the bottom.
What is secured inside the bottom of the lower half of the case?	A bronze flange to hold the stuffing box.
How is it secured?	It is sweated and screwed.
Of what does the stuffing box consist?	Of a composition stock screwed through the bronze flange, with a red-lead joint to make it water-tight.
How is the inside of the stuffing box fitted?	The stock is bored axially for the reception of an ebonite insulator, through the center of which 2 spring terminals are inserted by screwing together, thus making an insulated connection through the mine case.
How are the ends of the stock fitted?	They are threaded externally to receive a water cap, and the ends are bored out smooth to receive the spherical rubber packing.

NAVAL DEFENSE MINE—Continued.

THE MINE CASE—Continued.

Question.	Answer.
14. What is a water cap?	A screw cover that screws on the end of the stuffi box stock, compressing the spherical rub packing between it and the packing seat in the stock.
15. What are screwed into the water caps?	2 handles to afford a better hold for setting th down hard against the spherical rubber packin
16. What is furnished to protect the threads on the outer end of the stuffing box?	A bronze cap, with handle; it is also to facilit handling the mine.
17. When should this cap be removed?	Not until the mine is assembled for use.
18. What holds the two halves of the mine case together?	The clamps.
19. How many are there?	Twelve.
20. Of what do they consist?	Of double-lipped steel clamps with a square-h clamping screw passing through the upper straight lip, setting up against the flange of upper half of the mine case.
21. What is furnished for setting them up?	A T-wrench.
22. What is placed between the two halves of the mine case before setting them up?	A flat rubber gasket, $\frac{5}{16}$ inch thick, $1\frac{1}{2}$ inches wi and 32 inches inside diameter.
23. What steadies the rubber washer in assembling the mine?	The assembling ring.
24. Where is the circuit closer secured?	It is screwed to a flange in the top part of the up half of the mine case by 4 brass screws.
25. What are attached to the outside of the lower half of the mine case?	3 eyebolts, at equal distances apart, for attach the rods forming the tripod of the mov apparatus.

THE MINE CHARGE.

26. How many mine charges are there in each mine?	Four.
27. How may the mine charge be reduced, if it is desirable to do so?	By omitting one or more of the mine charges.

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NAVAL DEFENSE MINE—Continued.

THE MINE CHARGE—Continued.

	Question.	Answer.
28	Of what is the mine-charge case made?	Of sheet copper, No. 19 B. & S. gauge.
29	What is sweated to its top?	A bronze ring.
30	What screws into this bronze ring?	A bronze cover.
31	What is in the center of the bronze cover?	A stuffing box.
32	What is placed in the stuffing box?	A spherical rubber washer.
33	What covers the stuffing box and compresses the spherical rubber washer.	A water cap screwed on its outer end.
34	What is the dry-primer case?	A case of sheet copper to go inside the mine-charge case to hold the dry primer.
35	How is its top fitted?	With a circular flange.
36	How is the dry-primer case made water-tight?	By a rubber washer under and one over this flange.
37	What compresses these rubber washers?	The screw cover of the mine-charge case.
38	Why should the dry primer be separated from the rest of the mine charge?	To prevent it from absorbing moisture.
39	What is the dry weight of the mine charge?	31½ pounds.
40	What percentage of moisture does it contain?	25 per cent.
41	What is the weight of the wet charge?	39.3 pounds.
42	What is the weight of the dry primer?	2½ pounds.
43	How many blocks of wet cotton in the charge?	Fifty.
44	How many in the dry primer?	Four.
45	What is the complete dry weight of the charge for 1 mine?	136 pounds.

NAVAL DEFENSE MINE—Continued.

THE CIRCUIT CLOSER.

Question.	Answer.
46. What is the principle of the circuit closer?	It combines 2, the ball and socket and the vibrat
47. What is the shape of the case?	It is cylindrical and of brass.
48. What is in its lower end?	An ebonite plug held by 3 screws.
49. What is through the center of the ebonite plug?	A brass piece with a binding screw riveted to it
50. What is placed in the cylindrical hole in the lower end of the brass piece?	A compression spring of No. 12 A. W. G. phosph bronze wire.
51. What is in the upper end of the brass piece?	A recessed cavity with an axial hole bored in bottom.
52. What does the shoulder thus formed provide a seat for?	The tumbling weight or vibrator.
53. What is the vibrator made of?	Of brass.
54. What is its general shape?	That of a truncated cone, with a shoulder at lower end.
55. What is in the upper end of the vibrator?	A cup-shaped cavity.
56. What is placed in this cavity?	A brass contact ball.
57. What is around the large end of the vibrator?	A thin spring brass ring, slit into 16 tongues t project above the rim of the ball cap.
58. What is the use of these tongues?	To prolong the contact.
59. Why is the vibrator bored axially?	For the reception of the ball of the ball-and-soc joint by which it is held in its seat.
60. Where does the stem of the ball pass?	It is fitted with a screw thread at its lower end passes through the axial holes of the vibrator the brass piece and through the compress spring.
61. What is the adjusting nut?	A brass nut that screws over the ball stem co pressing the spring between it and the shoul in the brass piece.
62. How is the sensitiveness of the vibrator regulated?	By screwing up the adjusting nut more or le thus giving a greater or less degree of compress to the spring and holding the vibrator more less firmly down in its seat.

NAVAL DEFENSE MINE—Continued.

THE CIRCUIT CLOSER—Continued.

QUESTION.	ANSWER.
What retains the adjusting nut in position after adjustment?	A lock nut.
What is slipped over the upper end of the vibrator?	A cylindrical brass cover closed at its upper end.
How is it secure dto the shoulder on the ebonite plug?	By 3 screws.
What else passes through the ebonite plug?	A binding post, which projects from the bottom of the circuit closer.
How is the upper end of this binding post secured?	It is split and slipped over the lower edge of the cover.
How is it secured to the cover?	By a screw.
Why are the contact ball, the cup and springs, and the inside of the cover silver plated.	To prevent corrosion and insure a good electrical contact.
9. How is the circuit closed in the circuit closer?	By the shock of a vessel striking the mine or by the disturbing influence of the wave from a passing vessel, causing the vibrator to roll in its seat, and the ball will close the break between the cup and the top of the cover.

THE MOORING APPARATUS.

1. What is the mooring tripod?	It consists of 3 machine-steel rods with their upper ends hooked to the external eyebolts of the mine case, and their lower ends terminating in a shoulder with a screw nut.
2. In how many pieces is the segmental mooring block?	In 3.
3. What is it made of?	Of cast iron.
4. What is the broad shallow score around the outside of the segmental blocks for?	The marline lashing.
5. What are they bored axially for?	To receive the mooring bolt.
6. How are they secured to the tripod legs?	Each segment has a hole drilled through it that slips over the shoulder on the lower end of the tripod leg and is held in place by a screw nut.

NAVAL DEFENSE MINE—Continued.

THE MOORING APPARATUS—Continued.

Question.	Answer.
77. What serves to steady the blocks when they are assembled, and prevents the blocks rusting together when they are submerged?	Conical projections on one face of each segment abut in shallow conical cavities of smaller diameter in the adjoining face of the next segment.
78. What is the mooring bolt?	A single eyebolt, its upper end having a rivet head and the lower end terminating in an eye.
79. Why is 3 inches of its upper end smaller in diameter?	So that the segmental mooring block will fit snugly around it, and, when lashed together, will have no motion around it.
80. What are fastened to the mooring bolt?	The mooring and stray lines.
81. Of what are these lines made?	Of $\frac{3}{8}$-inch galvanized steel wire rope.
82. What is the length of the mooring line?	80 feet.
83. What is the length of the stray line?	50 feet.
84. How are they fastened to the mooring bolt?	They are spliced in with a thimble.
85. Where is the other end of the mooring line fastened?	To the reel of the automatic anchor.
86. How is the other end of the stray line fitted?	With a thimble.

THE AUTOMATIC ANCHOR.

87. Where does the automatic anchor get its name?	From the fact that the automatic arrangement contained within it permits the mooring of the mine to which it is attached at any predetermined submersion without a knowledge of the depth of water where the mine is dropped, the only limitation being that the depth of water be not greater than the entire length of the mooring line plus the vertical height of mine and tripod plus the submersion of the mine.
88. What is the general shape of the anchor?	Mushroom shaped.
89. Of what is the body of the anchor made?	Cast iron.

NAVAL DEFENSE MINE—Continued.

THE AUTOMATIC ANCHOR—Continued.

QUESTION.	ANSWER.
0. Where is the opening into the body?	At the top.
1. Why is the interior cored out?	For the reception of the reel and other internal parts.
2. What are the two standards cast inside the body for?	To carry at their upper ends bearings for the reception of the reel axle.
3. Where are the three holes bored through the body of the anchor?	One through the bottom, for the distance line, another through the side, in line with the axle of the reel, to permit shipping the crank, and the third also through the side, for the introduction of the bolt forming the pivot of the pawl.
4. Of what is the cover made?	Cast iron.
5. How is it secured to the body?	By 2 screw bolts introduced through holes in recessed cavities in the cover and screwing into tapped holes in the body.
6. Why are there 2 interior ribs in the cover projecting inside the flanges of the reel?	To keep the mooring line from jumping.
7. What is the cylindrical hole in the top of the cover for?	To reeve the mooring line through.
8. What is the wrought-iron handle at the top of cover for?	For slinging and handling.
9. What is the reel?	A drum with wide flanges made of malleable iron.
0. How is it made?	It is cast in one with the axle and is cored out for lightness.
1. What are on the ends of the axle?	Sleeves of bronze.
2. Where do they rest?	In bronze bearings on the standards.
3. What is in the end of the axle opposite the hole in the body of the anchor?	A square hole, to permit shipping the crank.
4. Where is the mooring line attached to the reel?	To a hole in the angle between the drum of the reel and one of the flanges.
5. How is it fastened?	It is rove through the hole from in out and has a knot turned in it.

NAVAL DEFENSE MINE—Continued.

THE UTOMATIC ANCHOR—Continued.

QUESTION.	ANSWER.
106. What are on the face of the reel?	4 studs squared on one side.
107. How are they secured?	They are let into holes in the frame of the reel at equal distances apart and are secured in place by machine screws.
108. Where does the crank ship?	Through the hole in the body of the anchor in the square hole in the axle of the reel.
109. How is the crank turned to reel up the line?	With the arm.
110. What is the pawl?	A stout machine-steel lever pivoted at right angles to the axis of the reel.
111. What is under its outer arm?	A spiral spring seated in a hole in the body of the anchor.
112. What does this spring do?	When it is not contracted by the pull of the distance weight, it holds up the outer end of the pawl and keeps the inner end engaged with one of the studs on the face of the reel, restraining the mooring line from unreeling.
113. Why is the inner end of the pawl beveled?	To insure a good surface for holding.
114. What is the distance line?	A galvanized steel wire rope $\frac{3}{8}$ inch in diameter, 24 feet long.
115. Where is its upper end fast?	It is rove through the hole in the bottom of the anchor and is spliced to the eye of the pawl lever.
116. What is the distance weight made of?	Lead.
117. What is its weight?	50 pounds.
118. Why is it bored axially?	So that the distance line may be rove through it.
119. How is the distance weight secured to the line?	It is slipped along the line to a distance from the bottom of the anchor, depending on the amount of submergence desired, and the free end of the line hitched snugly around its own standing part.
120. Where is the brake tube attached?	To one of the bearings for the reel axle.
121. What does it inclose?	A spiral spring.
122. What does this spring press against?	A traveling head that bears upon the center disk of the reel.

NAVAL DEFENSE MINE—Continued.

THE AUTOMATIC ANCHOR—Continued.

Question.	Answer.
3. Why is the tube threaded internally at its outer end?	To secure the adjusting plug.
4. What is the adjusting plug for?	To vary the amount of compression of the spring and regulate the pressure of the brake.
5. What is the object of the friction brake?	To prevent any unreeling of the mooring line except when the weight of the distance-line weight is pulling down on the distance line and pawl and the weight of the anchor is on the mooring line.
6. What is the weight of the anchor and mooring line in air?	530 pounds.
7. What is their displacement in sea water?	80 pounds.
8. What, then, is their effective weight in sea water?	450 pounds.
9. What is the weight of the loaded mine and accompanying parts in air?	480 pounds.
0. What is its displacement in sea water?	680 pounds.
1. This gives a reserve buoyancy of how much?	200 pounds.
2. What is the principle of the slow-sinking anchor?	It has an air chamber that reduces its weight in water while its weight in air is the same.
3. How is the anchor brought to full weight after it reaches the bottom?	The air-chamber fills with water.
4. How is the old type automatic anchor converted into a slow-sinking anchor?	Enough of the metal is machined away from the body of the anchor to make up for the new metal introduced and a sheet steel cylinder 17 inches high and 24 inches in diameter closed at the top is slipped over it and fastened with machine screws.
5. How does the mooring line pass through the top of this cylinder.	There is a hole cut for this purpose.
6. How is the crank introduced to reel up the moving line?	There is a hole opposite the crank hole in the body of the anchor.

NAVAL DEFENSE MINE—Continued.

THE AUTOMATIC ANCHOR—Continued.

Question.	Answer.
137. Is the cylinder water-tight?	No; water can enter through the mooring-line [illegible] and the crank hole.
138. What is the weight of the distance weight for the slow-sinking anchor?	100 pounds.
139. What is the weight of the slow-sinking anchor in air?	520 pounds.
140. What is the weight of the slow-sinking anchor in sea water before the cylinder is filled with water?	188 pounds.
141. What is the weight of the slow-sinking anchor in sea water after the cylinder is filled with water?	440 pounds.
142. What precautions must be taken before letting go the anchor?	(1) See that the friction brake has a moderate t[illegible]sion. (2) See that the pawl lever has been lifted by [illegible] distance weight. (3) See that the pawl engages when the dista[illegible] line is slackened. (4) See that the anchor is lowered close to the s[illegible]face of the water.
143. What is meant by a moderate tension on the friction brake?	A tension which will allow a man to revolve t[illegible] drum freely by pulling on the anchor line w[illegible] one hand, at the same time letting him feel t[illegible] the reel will stop turning the moment he st[illegible] pulling.
144. If the tension is too strong, what will happen?	The outer turn of the wire will jam itself among t[illegible] turns below it.
145. If there is too little tension, what will happen?	The drum will unreel so rapidly as to foul the wi[illegible]
146. In both cases what will happen to the mine?	The mine will go below its set depth.
147. If the pawl lever has not been lifted by the distance weight, what will happen?	The reel will not operate and the mine will go b[illegible]low set depth.
148. If the pawl does not engage when the distance line is slackened, what will happen?	The reel will continue to revolve until the anch[illegible] strikes the bottom and the mine will float.

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NAVAL DEFENSE MINE—Continued.

THE AUTOMATIC ANCHOR—Continued.

Question.	Answer.
1. What is sometimes the cause of the pawl failing to engage when the distance line is slackened?	Throwing the distance weight overboard with too much force allowing it to bring up with a jerk, jamming the spring or the plunger.
1. If the anchor is not lowered close to the surface of the water, what may happen?	The anchor may overtake the distance weight, the distance line will slack, and the mine will sink below its depth.
1. Can this last happen to the slow-sinking anchor?	No.

THE LEADING WIRE.

1. What is the length of the mine leading wire?	400 feet.
1. What kind of wire is used?	A single conductor cable of 15 strands No. 21 A. W. G. pure copper wire, well tinned and laid up in a strand, and insulated with okonite or rubber, and taped and braided to a finished diameter of ½ inch.
1. What has it at each end?	A terminal, one to connect to the battery box and the other to the mine stuffing box.
1. How may it be marked to show the direction of the battery box?	At each 10 feet secure two stops side by side, the stop nearest the mine having a knot in it to indicate the direction of the mine.
1. What is the additional 6 feet of this wire issued for?	To connect from the mine stuffing box to the circuit closer; it has a terminal on its lower end.
1. What is furnished to make the other interior connections?	Short lengths of single conductor cable, 7 strand No. 21 A. W. G., insulated to an external diameter of ¼ inch.
1. What is secured to the mine leading wire?	The stray line is stopped to it at short intervals.

BATTERY BOX AND BATTERY.

1. Of what is the battery box made?	Of bronze.
1. How is the bronze cover secured?	It is fastened down over a pure rubber washer with 8 brass screws ⅜ inch in diameter.
1. What is in the center of the cover?	A stuffing box.

NAVAL DEFENSE MINE—Continued.

BATTERY BOX AND BATTERY—Continued.

QUESTION.	ANSWER.
162. What else is on the top of the cover?	2 eyes.
163. What secures the stuffing box when the battery is not in use?	A bronze screw cap with handle; it also serves r convenience in handling.
164. Of what does the battery consist?	Of four small, round, dry cells $2\frac{1}{2}$ inches in dia- eter by $6\frac{5}{8}$ inches high.
165. What is the E. M. F. of each cell?	1.5 volts.
166. What is the internal insistance of each cell?	It is not to exceed 0.3 ohm.
167. How are the cells connected?	In series.
168. How is the ground made?	A Tobin bronze screw, with brass washer, scre into one side of the battery box inside near t top for a ground connection for one leg of t battery box.
169. How are the cells held in the battery box?	They are first insulated from the box by cardboa and then melted pitch is run in until the box full.

PREPARATION AND ASSEMBLING OF THE MINE.

170. How is the mine charge primed?	Take the mine charges out of their packing boxe remove the screw cover of the cases, wipe t primer cases dry inside and insert dry gun-cott primers of four 2-inch blocks.
171. What is done to the threads and the rubber washers before putting them in place?	Wipe the threads carefully, cut a section out of t rubber washer for the screw cover of the mi charges, and screw down the cover loosely.
172. Why is a section cut away from the rubber washers and the cover screwed down loosely?	So that should the mine case leak water will b admitted to the detonator and dry primer ar drown them.
173. What would happen if the mine case leaked enough to sink and the mine charge was not drowned?	Upon reaching the bottom the mine would roll one side, the contact ball would roll in its cu and the mine would explode.

NAVAL DEFENSE MINE—Continued.

PREPARATION AND ASSEMBLING OF THE MINE—Continued.

QUESTION.	ANSWER.
174. How are the detonators tested?	Brighten the legs of each detonator, attach them to suitable lengths of insulated wire, put each detonator successively in a safe place, connect the insulated wires to the terminals of a testing magneto, and turn the crank. Ringing of the magneto bell will indicate continuity of circuit and is presumptive evidence that the detonator is good.
175. What makes a good place in which to put a detonator to be tested?	An empty shell; enter the detonator through the fuze hole.
176. How are the detonators spliced on for service?	Remove the water caps and rubber balls from the screw covers of the mine charges and reeve them on the detonator connecting wires, the spherical rubber packing to be 5 inches from the top of the detonator case. One splice must be ½ inch from the detonator and the other 1 inch from the spherical rubber packing.
177. How are these splices made?	Remove so much of the insulation as may be necessary, brighten the exposed wires, being careful not to nick them, place the insulation of the detonator legs alongside that of the detonator connecting wires, with the ends of the insulation flush; expand the bared detonator legs in turns around the bared detonator connecting wires, turn the ends of the detonator connecting wires back over the splices and trim off the ends.
178. How are they insulated from metallic contact?	Insulate the splice nearest the cover of the mine charge with twine or okonite tape, and pass a few turns of the tape around the detonator legs to stiffen them for inserting in the primer hole.
179. How are the detonators connected together?	2 in series and 2 in parallel.
180. What care must be taken in making the insulation?	Not to make it too bulky.
181. How is the circuit closer tested?	Attach its binding posts to the terminal of a testing magneto and turn the crank.
182. With the circuit closer upright what should be the result?	The circuit should remain open.
183. With the circuit closer tilted to one side what should be the result?	The circuit should be closed and the magneto bell ring.

NAVAL DEFENSE MINE—Continued.

PREPARATION AND ASSEMBLING OF THE MINE—Continued.

Question.	Answer.
184. How is the sensitiveness of the circuit closer regulated?	By screwing up or down on the adjusting nut so that when the circuit closer, held upright, is struck a sharp blow the break may be momentarily closed; then screw up the lock nut.
185. What is attached to the circuit-closer binding posts?	The band end of the 6-foot length of mine leading wire to one and one of the detonator connecting wires to the other.
186. How is the upper half of the mine case held for loading?	It is turned upside down and placed in a grommet on deck to keep it frem rolling.
187. What is the first step in loading?	Screw the circuit closor to the flange in the top of the mine case.
188. What is the second step?	Bolt the mine-charge frame in place, seat the mine charges in the frame. and secure with the side rods, clamping bar and nuts.
189. What is the third step?	Align the holes in the dry primers with the rectifier, insert the detonators, and set up the water caps loosely.
190. What is the fourth step?	Attach the remaining end of the detonator connecting wire to the ground screw in the mine case.
191. What is the fifth step?	Attach the terminal end of the 6-foot mine leading wire to the inside stuffing box in the lower half of the mine case, being careful to set up the water cap tightly.
192. What is the sixth step?	Put the 2 halves of the mine case together with the rubber gasket between, put on, and set up on the clamps.
193. What care must be taken with the water caps outside the mine case?	They must be set up very tightly.
194. What would happen if they were not?	They would leak, cause a ground, and run the battery down in a very short time.
195. If circumstances permit, how often should the battery boxes of planted mines be tested?	Once a week.
196. If the battery shows signs of running down what should be done?	The mine itself should be raised, the stuffing boxes, gaskets, and cable examined and the defect remedied, a new set of batteries installed, and the whole replanted.
197. What is done with the 400-foot length of mine leading wire?	Its terminal is seated in the spring socket in the mine case stuffing box from the outer end, seat the rubber washers, and screw up the water cap.

NAVAL DEFENSE MINE—Continued.

PREPARATION AND ASSEMBLING OF THE MINE—Continued.

Question.	Answer.
198. What care must be taken in doing this?	Be careful to get the proper end as indicated by the knot on the 2 stops at intervals on the leading wire.
199. What is done with the tripod legs?	The segmental blocks are secured to them, and they are hooked to the eyebolts on the bottom half of the mine case.
200. What should be done with the hooks?	They should be securely moused.
201. What is done with the segmental block?	The segments are brought together, with the mooring bolt in its proper place, and they are firmly lashed with a flat siezing of marline completely filling the score.
202. What is done with the stray line?	It is stopped to the mine leading wire for its full length. The stops should be 5 feet apart.
203. How is the distance weight secured?	Slip it up the distance line until the distance from the lower end of the weight to the bottom of the anchor is equal to the desired submersion plus the correction. Secure the weight in place by hitching the end of the distance line around its own standing part.
204. What is done with the mooring line?	Wind up its slack on the reel and unship the crank.

CARRYING OUT AND PLANTING MINES.

205. What is the distance between mines?	125 feet.
206. If they are closer than this what will happen?	The explosion of one mine will damage the circuit closer of the others within this range.
207. Upon what do the details for planting mines depend?	Upon the facilities at hand, the nature of the particular occasion, and the location.
208. What is very important?	To have the mines located in the predetermined position.
209. If the conditions of tide or current are such as to render it very difficult, what may be done?	First plant a weighted line at the exact position selected, having attached, at the desired intervals, appropriate lines with small floats to indicate the positions at which it is desired to drop the mines.
210. In planting mines what is the first thing to remember?	That the battery box must not be connected to the mine leading wire until the mine is planted and the mine leading wire run out to its full length.

NAVAL DEFENSE MINE—Continued.

CARRYING OUT AND PLANTING MINES—Continued.

Question.	Answer.
211. Why is it better not to have the battery box in the same boat with the mines?	To prevent any possible chance of their being connected before the proper time.
212. What boats are usually used for planting mines?	Sailing launches.
213. What is removed from the launch?	Everything except four oars.
214. How should the launch be rigged?	Lengths of 2 by 3 inch timbers should be placed thwart-ship of the launch with a cleat at each end on the under side to prevent their slipping; four 2-inch planks should be laid fore-and-aft over these timbers and spiked to them, two on each side of the boat. One plank should be flush with the gunnel of the boat and the other about 12 inches from it.
215. What mine connections should not be made until after the mines are in the boat?	The mine leading wire should not be connected to the mine nor the mooring bolt to the segmental block.
216. Why should not the connections be made?	So that in loading the boat the mines and anchors may be handled separately.
217. How should the anchors be lowered?	Pieces of wire or hemp should have an eye spliced in one end and secured in the boat, so that the eye will lay over the gunwale. A small strap or grommet should be spliced in the handle of the anchor. Lower the anchor over the side of the launch, reeve the grommet through the eye, and put a squilgee, preferably of metal, through it; a small hole through the small end of the squilgee with a pin in it will prevent any accidental dropping of the anchor.
218. How should the mines be lowered?	They should be lowered into the boat, resting in the space between the two planks and directly over the anchor.
219. How should the mine-leading wire be lowered?	Place the reel in the boat and unreel 50 feet, to allow stopping on the stray line and the sinking of the mine, then connect it to the mine.
220. What other connections should be made?	Connect the mooring bolt to the segmental block and stop the stray line to the mine-leading wire.
221. Where should the tail of the squilgee be fastened?	To the mine case.

NAVAL DEFENSE MINE—Continued.

CARRYING OUT AND PLANTING MINES—Continued.

Question.	Answer.
How is the mine dropped?	When the launch is over the desired spot the distance weight is eased over the side and the mine case rolled overboard, taking care that the part of the mine-leading wire unreeled is clear for running. The weight of the mine case falling on the squilgee tail pulls the squilgee out and drops the anchor.
What is then done with the mine-leading wire?	The reel is passed to the battery-box boat, which runs off to at least 350 feet from the mine, connects the battery box to the mine-leading wire and drops them overboard.
In what direction from the line of mines is the battery box placed?	At right angles.

PICKING UP MINES.

Question.	Answer.
What boat should be used grappling the wire?	A dinghy or small boat.
How is the grappling done?	Pull back and forth over the location of the mine-leading wire until the grapnel takes hold.
When the grapnel is hauled up and the mine-leading wire reached, what is done?	Underrun the wire until one of the marks indicates the direction of the mine. Then underrun the wire until the battery box is reached and removed.
After the battery box is removed, what is done?	Underrun the wire in the opposite direction, coiling it down clear as it comes in, until the end of the stray line is reached.
What is done with the stray line?	It is passed to the launch.
How is the stray line used to raise the mine?	Take it over the stern roller of the launch and then a snatch block in the bow. Haul in until the mooring bolt comes up (cutting the stops as they come up), and then securing a line to some part of the mine, cut the marline seizing around the segmental block. Make fast the mine alongside. Haul in on the mooring line until the anchor is weighed, then reeve a slip stop through the handle and make it fast.
How can the mine and anchor be lifted on board a launch?	By rigging a pair of sheer legs in the stern and using a tackle.

NAVAL DEFENSE MINE—Continued.

CARE OF MINE OUTFIT AFTER BEING USED.

Question.	Answer.
232. What should be done with the mine case and explosives?	Disassemble the mine case, disconnect and ta out the detonators, and dry primers, and st them away; also the mine charges.
233. What should be done with the mine-leading wire?	Test it for continuity and flake it down to d before stowing away.
234. What should be done with the battery?	Test it with a voltmeter.
235. If they have run down, what should be done?	The cells should be renewed, as they will never r cover.
236. What should be done with the anchor?	Open it, dry all the parts, then give them a coati of hot vaseline applied with a brush.
237. What should be done with the mooring, stray, and distance lines?	Give them a coating of hot white lead and tallo

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CHAPTER VII.

COUNTERMINES.

Question.	Answer.
38. Of what does a naval countermine outfit consist?	10 sheet-iron, loaded, countermine cases; 10 primer cases; 10 countermine buoys; 3 channel buoys; 3,600 feet of single conductor cable; 50 galvanized-iron shackles; 2 primer boxes containing dry gun-cotton primers; 1 detonator box; 20 testing-fuse bridges; 1 supply box; 1 chemical box.

THE COUNTERMINE CASE.

9. What is the shape of the countermine case?	Cylindrical.
0. Of what is it made?	Of sheet iron.
1. What is its size?	Extreme length, $44\frac{1}{4}$ inches; outside diameter, $22\frac{1}{4}$ inches.
2. What is the weight of the wet gun-cotton charge?	529 pounds.
3. What percentage of moisture does the charge contain?	25 per cent.
4. How is the wet charge introduced?	Through a manhole in one end.
5. How is the manhole closed?	By a plate bolted on with screw bolts over a rubber washer.
6. What is secured to the other end?	A water-tight guard for the reception of the primer case.
7. How is the open end of this guard closed for transportation and stowage?	By a wooden cover.
8. How is the wooden cover secured?	By the follower ring.
9. How else may this cover be used?	For temporarily covering the end of the dry primer and keeping it in place during the preparation of the countermine.

COUNTERMINES—Continued.

THE COUNTERMINE CASE—Continued.

QUESTION.	ANSWER.
250. What are the lugs on each end of the countermine case for?	For stopping on the cable, etc.
251. What is the average gross weight of a countermine?	759 pounds.

PRIMER CASE.

QUESTION.	ANSWER.
252. What is the shape of the primer case?	Square.
253. What does it contain?	The dry primer.
254. What is the weight of the dry primer?	5 pounds.
255. Where is the primer case placed in the countermine case?	In the primer-case guard.
256. How is it secured in place?	By a follower ring, screwed down hard on top of e primer-case cover, a rubber washer being in-posed between it and a shoulder on the prir case.
257. What is in the center of the primer-case cover?	A stuffing box.
258. What is the stuffing box for?	To provide a water-tight entrance for the detonar leading wires.
259. Of what does the stuffing box consist?	Of a seat for a spherical rubber packing throu which pass two holes for the detonator lead wires, and a water cap and friction ring, whi screws down on the rubber packing, presses t water-tight in its seat and around the wires.

THE MINE CABLE.

QUESTION.	ANSWER.
260. Of what does the mine cable consist?	Of 3,600 feet of single-conductor cable; made of strands of No. 21 A. W. G., well tinned cop wire, insulated with rubber or okonite to a fi-ished diameter of ½ inch.
261. What is the resistance per 1,000 feet of the mine cable?	1.9 ohms.
262. What care must be taken in making all splices?	To make them water-tight and to prevent a strain from coming on them.

COUNTERMINES—Continued.

THE MINE CABLE—Continued.

Question.	Answer.
63. How is strain prevented?	By seizing cuckold's necks in the cables at the splices and by seizing the branch cables to the lugs on the mine case.
64. What are furnished to make the ground connections?	Earth wires and earth plates.
65. What may be used in place of the earth plate?	The mine case itself, care being taken to make a good electrical connection between it and the ground wire.
66. What are furnished to make the single and branch splices?	Metallic splice insulators.
67. What is a metallic splice insulator?	A hollow metal cylinder terminated at each end by a stuffing box similar to that in the primer case. An interior lining of insulating material in the cylinder prevents a short circuit of the splice with the metal of the cylinder.
68. How is a simple splice made with the splice insulator?	Remove the linen braid from the two ends to be spliced for such a distance that it will be outside the insulator when the splice is complete and put a whipping on over the linen braid. Remove the rubber tape from the exposed insulation. Bare and brighten the conductors of each wire and reeve the end of each wire through a water cap and a single-hole spherical rubber packing. Slip the cylinder of the splice insulator over the end of one of the wires and then join the 2 conductors by a snug square knot or sheet bend. To insure close electrical contact and to keep the conductors from working loose in subsequent handling of the wires, separate 2 wires of each conductor after the square knot or sheet bend is made, trim the remaining wires, twist the separate wires together and wrap them around one of the conductors, solder it if it is to be permanent, and wrap with okonite tape. Slip the cylinder of the splice insulator over the splice, slide the spherical rubber packings into their seats, and screw down the water caps. Turn a cuckold's neck in the wire and seize it to take off any strain.
69. How is a branch splice made with a metallic splice insulator?	Cut the main cable at the point where the branch is to be made and prepare the 2 ends at cut and the end of the branch, as for making a simple splice. Slip a water cap over the 2 cut ends of the main cable and reeve the 2 ends through a double-hole spherical rubber packing. Slip a water cap over the end of the branch wire, reeve its end through a single-hole packing, and slip

COUNTERMINES—Continued.

THE MINE CABLE—Continued.

Question.	Answer.
	the splice cylinder on. Join the 2 ends of tl main conductor and the end of the branch co ductor by a square knot or sheet bend; sold and wrap with okonite tape. Siip the cylind over the splice, seat the rubber packings, an screw down the water caps. Turn in and seiz a cuckold's neck to take any strain.
270. How is a simple splice made without a special splice insulator?	The wire is prepared and the splice made in tl same way as when the special splice insulator used, except that a rubber tube is slipped ov one of the wires instead of an insulator cylinde After the splice is made the rubber tube is pulle over the splice and a tight seizing is put tightl around each end, binding the tube into clos contact with the insulation of the wire. Th usual cuckold's neck is turned in and spliced.
271. How is a branch splice made without a special splice insulator?	Remove the linen braid for about 2½ inches fro the main wire at the point where the branch i to be placed and put a sizing on the linen braic Remove the rubber tape from the exposed insu lation and clean off the paraffin carefully. Re move the insulation for about ½ inch in the mic dle of the exposed insulation, being careful nc to cut or nick the conductor. Brighten the cor ductor and bind it into a bight. Remove line braid, rubber tape, and paraffin similiarly fo about 2 inches from the end of the branch wir and expose and brighten about 1 inch of th conductor. Join the conductor of the branc wire with the bight in the conductor of the mai wire by a snug sheet bind. Wrap the splic with fine wire and solder it. Then insulate th splice with a parceling of okonite tape, workin from the exposed conductors of the splice towar and around the insulation, warming the okonit tape and pressing it into adherent contact witl the insulation, taking care not to overheat th okonite tape. Continue the parceling, warmin and pressing each layer until the splice is wel turned in, and then wrap it with a protectiv sizing of flax twine. Turn in and size cuckolds neck.
272. How many detonators are used in each mine?	Two.
273. How are they connected?	In arc.
274. How are the splices made?	Strip the braiding and rubber tape from the branch and earth wires for at least 6 inches from the ends and put on a neat whipping. Arrange so that the water cap and spherical rubber pack-

COUNTERMINES—Continued.

THE MINE CABLE—Continued.

Question.	Answer.
	ing can be slipped over them. The spherical rubber packing being 5 inches from the bottom detonator case of the upper detonator, the splices being between the detonator and the rubber packing. Remove so much of the insulation as may be necessary for making the splice from the leading wire and from the legs of the detonators. Place the insulation of the detonator legs alongside that of the leading wires with the ends of the insulation flush, and expand the bared detonator legs around the bare conductors of the leading wires. One splice should be ½ inch from the detonator and the other 1 inch from the rubber packing. Remove so much of the insulation as may be necessary from the legs of the second detonator, brighten the exposed wires and wrap them, one around one of the splices of the first detonator and the other around the other splice, the second detonator to be below the first when the splice is finished. Turn the ends of the conductors of the leading wires back in a hook over the turns of the detonator legs, pinch them down snugly, and trim off the ends. Insulate from metallic contact the splice nearest the water cap with okonite, and pass several turns of the tape neatly around the detonator legs to stiffen them.

MAKING UP AND TESTING THE LINE.

75. What is the proper distance apart for the mines in water from 26 to 48 feet in depth?	180 feet.
76. If the depth is greater than 48 feet, what must be done?	The mines should be closer together.
77. How is the wire furnished?	On reels.
78. Where is the fitting done?	On board ship, according to the requirements of the case.
79. Ten counter mines are to be laid 180 feet apart. How far from the end of the main cable should the first branch splice be made?	660 feet.
80. How long should the branch wire be cut?	According to the depth of water where the mine is to be laid.

COUNTERMINES—Continued.

MAKING UP AND TESTING THE LINE—Continued.

QUESTION.	ANSWER.
281. What should always be used, if available?	Metallic splice insulators.
282. After splicing the branch wire to the main cable what should be done with its other end?	It should be prepared to receive the detonator.
283. How long is the ground wire?	3 feet.
284. How much of the mine cable should be allowed between mine buoys?	200 feet.
285. What is the extra 20 feet for?	To allow sufficient slack wire to keep strain off it.
286. Before planting mines what must be done?	Be sure that the water caps on all splices and mines are set up water-tight to prevent any leaks.
287. How many amperes are required to fire 20 detonators connected in parallel?	10 to 12 amperes, if all connections and the insulation are perfect.
288. How much should be allowed for imperfect connections?	A battery power of at least twice this amount.
289. After all splices, except detonator splices, are made how can assurance of continuity and battery power be had?	Connect 2 fuse bridges, in arc, with each branch at the place which the detonator will occupy; connect at each end the firing apparatus to be used, leaving a break; make the earth connections and put on the firing current at the two ends simultaneously. Flashing of the dry gun cotton wisps with which the fuse bridges are wrapped will prove continuity and a sufficient firing current.

FITTING THE COUNTERMINE LAUNCH.

290. What boat is used?	The largest sailing launch at hand.
291. What are fitted to her?	6 special thwarts extending from gunwale to gunwale and securely lashed.
292. How are their distances apart regulated?	To give room for the mines and to distribute the weight equally on the boat so as to keep her in trim.
293. How are the mines arranged?	Around the side of the boat.

COUNTERMINES—Continued.

FITTING THE COUNTERMINE LAUNCH—Continued.

Question.	Answer.
How are they secured?	By slings.
How are the slings secured?	The ends of the slings of each mine hook to eyebolts in the side of the launch; each sling is then carried over a tripping latch secured to the thwart.
Where are the countermine buoy ropes, with the branch wire attached, coiled?	On top of the countermines, forming a nest for the buoys.
How are these buoys held in place while fitting the countermines?	By a rope yarn which must be cut before laying operations commence.
What are the channel buoys for?	To mark the cleared channel.
What make good channel buoys?	Oil barrels coppered to insure their being watertight.
Where are the channel buoys placed?	The two end buoys are 90 feet from the end mines and the middle buoy is midway between Nos. 5 and 6 mines.
How are the channel buoys placed in the minelaunch?	1 over the stern, 1 amidships on the starboard side, and 1 on the port bow.
How are their anchors placed?	They are slung directly below them with the anchor line coiled on top of the buoy and held in place by a single rope yarn.
What may be attached to the buoys at night?	A calcium phosphide light to indicate the channel.
How is the distance line, with main cable attached, secured?	It is coiled up on the outside of the mines, and to enable them to run clear hangs every three or four turns by split rope yarns which carry away in succession as the strain comes on them.
How is the distance line and cable passed from mine to mine?	Underneath the boat.
What trips the mine?	The distance line is made fast to the tripping hook and, when a strain comes on it, releases it.
When all preparations for dropping the mines are complete what is done?	Enter the detonators in the primers and set up on the water caps.

COUNTERMINES—Continued.

LAYING THE COUNTERMINES.

Question.	Answer.
308. After the launch is prepared what is done?	She is taken in tow by a steam launch or vessel f light draft.
309. Why should a short painter be used?	To prevent her taking rank sheers when a mine dropped.
310. What is done with the outer end of the cable?	It is left on board the leading ship, if possible, else in a boat which anchors so as to be shelter by the ships from the fire of the enemy.
311. What is the use of this boat?	It is to insure the firing of all countermines in c of the breaking of the main cable, etc.
312. How are the countermines dropped?	The steamer with the countermine boat in tow p ceeds at full speed, steering a straight course o given bearing. The men in the countermi boat drop the first buoy by hand at the spot wh the channel known to be clear finishes. If t launch is fitted for automatic tripping, the el tric cable with reenforcing line pays itself out carrying away the stops in succession until comes to the point where it is attached to t slip of the first mine. It slips this with its bu and then goes on paying out automatically un it comes to the next mine, which it lets go in t same way, and so on in succession until the wh are dropped.
313. If the tripping is not done automatically, how are the mines let go?	Each mine and buoy must be dropped by hand the proper moment by the boat's crew.
314. How many lines of mines should be laid at the same time?	2 parallel lines, the two steamers keeping their e act distance from each other as they steam in.
315. How should the lines of mines be laid in reference to the channel?	Lengthwise of the channel.
316. If arrangements are made to drop the mines automatically, why should the boats have men in them?	2 or 3 men should be in each boat ready to a in case of anything going wrong. The aut matic arrangement enables the mines to dropped with much greater rapidity and acc racy than could be done by hand, but there always a chance of something going wro which a man on the spot can correct at once.
317. If the cable was cut by a shot or otherwise, what would have to be done?	The next mine would have to be dropped by ha for the operation to go on as before.

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COUNTERMINES—Continued.

LAYING THE COUNTERMINES—Continued.

QUESTION.	ANSWER.
3. What is a good time for laying and firing the countermines?	The time, of course, depends on the speed of the steamer, but it can be performed, under favorable circumstances, in 4 minutes from dropping the first buoy to firing the countermines.
3. If the steamer is stopped by obstructions, what should be done?	The cable should be cut and insulated in the countermine launch, and then, if far enough from the last mine dropped, the signal should be made to fire from the "home end" when those already laid may be fired.
3. How should the countermines be fired?	Simultaneously from both ends at a well-understood, prearranged signal.
3. Who should give this signal?	The officer in charge of the boat running out the line of countermines.
3 What current is advisable to use?	A dynamo current to insure a powerful current.
3 What are furnished to fire the mines?	Standard dry-battery cells for cases where the dynamo current is not available.
3 What care must be used in connecting up dynamos or batteries?	Be particular that the same poles in each case are connected to the main cable of the line.

CHAPTER VIII.

OBSERVATION MINES.

Question.	Answer.
325. Of what does an observation mine outfit consist?	Of 10 naval defense mines connected to a firg board on shore, and which is capable of firing ay one or a combination of any two mines at e same time.
326. What change is made in the interior connections of a naval defense mine when it is to be used as an observation mine?	The circuit closer is left out and the wires or-nally leading to it are spliced together.
327. In how many lines are the mines planted?	In 2.
328. How many mines in each line?	Five.
329. How far apart are the mines planted?	Maximum distance, 160 feet; mimimum distan, 148 feet.
330. How are the separate mines designated?	Each mine is given a number.
331. How are the two lines of mines designated?	One line is designated the "red range" and t other the "white range."
332. What number mines are on the red range?	Nos. 1 to 5, inclusive.
333. What number mines are on the white range?	Nos. 6 to 10, inclusive.
334. How are the mines connected with the junction box?	By single conductor wires.
335. Where is the junction box placed?	In rear and not less than 200 feet distant from t nearest mine.
336. How do the single conductor wires enter the junction box?	Through a water-tight stuffing box in one end.
337. Why are the wires leading from the red range anchored?	To prevent entanglement with the wires of t white range.
338. Of what do the multiple cables consist?	They are 2 in number, 1 of 7 conductors and 1 of

OBSERVATION MINES—Continued.

Question.	Answer.
339. What is the lead of the multiple cable?	From the firing board to the junction box.
340. How does it enter the junction box?	Through 2 stuffing boxes.
341. How are the single conductor wires spliced to the multiple cables?	The single conductor wire from each mine is spliced to one conductor of the multiple cable which leads to the plug segment of the firing board having the same number as the mine.
342. What is the eleventh wire of the multiple cable for?	It is the ground wire.
343. How is it grounded?	An electrical connection is made with it to the body of the junction box.
344. How does the return current get from the mine to the junction box?	Through the water.
345. What are the general connections for the mine field?	Each mine has a separate wire leading from its numbered plug segment of the firing board, through the junction box, through its detonators to the mine case, back through the water to the junction box, from which latter point all mines have a common return to the battery terminal.
346. What is done with the stray line of each mine?	It is stopped to the single conductor wire leading to the junction box.
347. Of what is the junction box made?	Of heavy cast bronze.
348. How is it closed?	By a removable bronze cover.
349. How is the cover secured?	By screw bolts.
350. How is it made water-tight?	By a rubber gasket.
351. What is at one end of the box?	A large stuffing box through which the 10 single conductor wires enter the box.
352. What is at the other end?	Two stuffing boxes through which the 7 and 4 wire cables enter the box.
353. How are these stuffing boxes made water-tight?	Heavy rubber washers are placed around the cables in the stuffing boxes, against which the water caps are set up hard.
354. After the splices are made and insulated what is done to prevent them from being broken by strains on the cable?	Clamps are put around the wires inside the junction box and bearing against the mouths of the stuffing boxes.

OBSERVATION MINES—Continued.

Question.	Answer.
355. What additional precaution is taken to make all splices in the junction box water-tight?	The splices are separated and a mixture of eq parts of tallow, beeswax, and rosin poured hot and allowed to cool.
356. Of what does the firing board consist?	Of the bus bar, common bus bar, plugs, plug s ments, resistance coil, sounder, and firing key
357. How is the bus bar connected?	One end is connected with the + terminal of t battery; the other end connects with one t minal of the resistance coil and also with o terminal of the firing key.
358. What does it carry in receptacles in its top?	The 10 plugs when they are not in use.
359. How is the common bus bar connected?	With 1 terminal of the firing key and also with terminal of the sounder.
360. How is the other sounder terminal connected?	With the resistance coil.
361. How are the mine-leading wires connected?	To the plug segments.
362. When one of the plugs is inserted into one of the segments how does the current pass from the battery?	From the battery it passes through bus bar, r sistance coil, sounder, common bus bar a through the mine circuit, which is plugged in.
363. If the circuit is complete what indicates it?	The sounder, while the firing key is open.
364. When it is desired to fire a mine what is done?	The mine is plugged in, the sounder indicates th circuit is complete, and the firing key is close This cuts out the resistance coil and sounde sending the full battery power through the min
365. When should the mine be plugged in?	Just before the moment of firing.
366. Why should not the circuits be tested too frequently?	It weakens the battery.
367. What precaution is to be taken in regard to the firing key?	It is never to be closed, except when a mine is t be fired.
368. What precaution is to be observed in regard to the cover of the sounder?	It must never be removed.
369. Why not?	It might not be put back in adjustment with tappe and would not indicate when testing.

OBSERVATION MINES—Continued.

Question.	Answer.
370. How many cells in the firing battery?	Seventy-six navy standard dry cells.
371. How are they connected?	In series.
372. How are they arranged?	In 2 compartments, upper and lower, of 38 cells each.
373. What is the E. M. F. of each cell?	1.5 volts.
374. What is the E. M. F. of 76 cells?	114 volts.
375. What is the internal resistance of each cell?	0.3 ohm.
376. What is the internal resistance of 76 cells?	22.8 ohms.
377. What is the cable resistance per 1,000 feet?	1 ohm.
378. What is the resistance of 5,000 feet of cable?	5 ohms.
379. What is the resistance of 1 detonator?	0.65 ohm.
380. What current is required for 1 detonator?	0.7 ampere.
381. What current is required for 1 mine?	2 amperes.
382. What completes the circuit from the battery to the bus bar of the firing board?	A bronze safety plug.
383. Where is it plugged in?	Into the minus terminal of the battery, under the box lid.
384. When is it plugged in?	When testing circuits or firing mines.
385. Where is it kept at all other times?	In a socket hole provided for it in the top of the side of the battery box.
386. How many battery boxes are there?	Two.
387. How are they fitted?	Both boxes are fitted with hinged covers, and the bottom one with hinged legs.
388. When the battery is assembled, how are the legs secured?	They are dropped down and secured with braces and pins.

OBSERVATION MINES—Continued.

Question.	Answer.
389. When the upper box is placed in position, what connections are made?	The brass strip connections are clamped to th terminal binding posts.
390. What is secured to the cover of the upper box?	The firing board.
391. Where does the common return from the mines connect?	At the minus terminal of the lower box.
392. Where does the plus terminal of this box connect?	By a brass strip running diagonally to the minu terminal of the upper box.
393. Where does the plus terminal of the upper box connect?	By another diagonal brass strip to the bus bar the firing board.
394. Where is the safety plug inserted?	In a socket recessed into the upper edge of the le side board of the upper box.
395. Why is it placed in this position?	It makes it necessary to disconnect one bindin post of the brass connecting strip and to rais the box cover, in order to plug in for testing.
396. Are both boxes fitted with safety plugs?	Yes; at the minus terminals.
397. How many methods of determining the location of the target are recommended?	Two.
398. Should the topography of the country or other circumstances be such as to preclude the possibility of establishing 2 stations to fix the position of the target by cross bearings, what may be done?	An observer at a single station may be employed.
399. If a suitable bluff or elevation can be found, with an unobstructed view of the mine field, how may the position of each mine be fixed?	By noting with a transit instrument the angle o depression at the station of the boat's water lin when each mine is planted, as well as its azi muth angle.
400. Where is it best to locate this station?	In line with the line of mines.
401. Why?	It would eliminate the necessity for azimuth angles.

OBSERVATION MINES—Continued.

Question.	Answer.
2. How may the operator determine which mine to use?	The observer sets his telescope at the azimuth of the mine field, and when the target is "on" reads the angle of depression of her water line, plugs in the mine corresponding to that angle, and presses the firing key.
3. If the station is not on the range of mines, how must the proper one be located?	By both azimuth and depression angles.
4. What is the error for this method?	±15 feet for ±1 foot of tide, assuming an elevation of 200 feet for a station 3,000 feet distant from the mine.
5. Should the single station be on low land, how may its distance from each mine be determined?	By known masthead angles of the planting vessel, triangulation, or cross bearings.
6. How may the observer know which mine to use on the approach of an enemy?	By azimuth and stadimeter (if the targets masthead angle be known) or by some other range finder.
7. What is the simplest and most accurate method of fixing the position of the mines?	It is to have two plane table stations.
8. What is the ideal position for two such stations?	Station A should be on a line with the red range and station B at right angles to it, looking directly down the channel.
9. Why is this the best position?	Because B can look directly down the channel and notify A some time in advance which mine the target will pass, then B can plug in that mine and, when the target comes on his range, fire it.
10. Where should the firing board be?	At station A.
11. How should the two stations be connected?	By telephone, there being established a prearranged system of signals indicating the number of the mine, or some other method for a complete understanding, such as an ordinary bell system annunciator, or series of electric lights.
12. What other system may be used?	Station B may be looped into the firing circuit, so that when the observer plugs in a certain mine, that circuit will only be complete when A plugs in the same mine.
13. What indicates the number of the mine plugged in by B?	An annunciator or other mechanical device with a buzzer in circuit.

OBSERVATION MINES—Continued.

Question.	Answer.
414. Give an example of the working of this system.	Observer B notes that mine No. 5 is to be use he plugs it in; observer A notes the buzzer a the drop 5 of the annunciator, plugs in 5 a awaits the approach of the target on his rang The target changes course, and B notes th mine No. 4 will be used, the withdrawal of B plug stops A's buzzer, and A withdraws his plug; B plugs in 4, A notes buzzer and drop of annunciator and plugs in 4. The target ge on A's range; the buzzer is still sounding. knows both lines of sight are on the targe presses the firing key, and the entire circuit completed through B's loop.

IMPROVISED MINES.

Question.	Answer.
415. What is an improvised mine?	A mine made from any material that may be o hand not regularly employed for that purpose.
416. Of what may the mine case be made?	Of a barrel, cask, tin can, or even a large gla bottle.
417. What explosive would usually be used?	Gunpowder.
418. How should a barrel be prepared?	It should be given a coat of hot pitch to insure it being water-tight and thoroughly dried out in side.
419. How should the powder be placed in the barrel?	Simply poured in through the bunghole until it i full.
420. What would ordinarily be used in place of the detonator?	An electric primer.
421. If the primer had but a single wire, how would the ground be made?	Wrap the barrel of the primer tightly with th bared end of an insulated wire.
422. Where would the wires lead from the barrel?	Through the bunghole.
423. How would the bunghole be made water-tight?	A soft wooden plug, with a score cut on each sid for the passage of the wires, would be drive tightly in the bunghole and then covered thickly with hot pitch.
424. What battery could be used to fire the mine?	At least 6 ordinary dry cells connected in series.
425. What wire may be used?	Any single-conductor wire with waterproof insula tion.

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OBSERVATION MINES—Continued.

IMPROVISED MINES—Continued.

	QUESTION.	ANSWER.
42	What may be done with the primer to insure ignition?	A small cloth bag, small enough to go through the bunghole, may be made, filled with fine black powder, the primer embedded in it, and the mouth of the bag gathered around the wires and tied. The bag is then pushed through the bunghole into the powder in the barrel.
42	How should the ground be made?	The wire that is attached to the primer by wrapping should have a plate of copper fast its end outside the barrel and a wire, ending in a copper plate, should lead from the minus terminal of the battery to the water.
42	What could be used in place of a firing key?	When all is ready simply touch the end of the single conductor wire to the plus terminal of the battery.

CHAPTER IX.

THE UNITED STATES ARMY MINE.

THE MINE CASE.

Question.	Answer.
429. What is the diameter of the buoyant mine case?	32 inches.
430. Of what is it made?	Of 10-pound, $\frac{1}{4}$-inch open-hearth steel of g t toughness and elasticity.
431. In how many parts is the mine shell made?	2 hemispheres.
432. How are these hemispheres held together?	They are ribbed and welded at the equator, th avoiding all rivets.
433. What test is given the mine case before acceptance?	It is subjected to a hydraulic pressure of pounds per square inch.
434. What is in the outside center of the upper hemisphere?	An eyebolt called the "maneuvering ring."
435. What is in the center of the lower hemisphere.	It is pierced by a $5\frac{1}{2}$-inch hole.
436. How is the edge of this hole reenforced?	By a welded ring $1\frac{1}{2}$ inches thick, into which t compound plug screws.
437. What are placed at equal distances around this hole?	4 bosses, also welded.
438. What do these bosses carry?	Screw bolts which project $2\frac{1}{2}$ inches outside to cure the cap.
439. What is the cap?	A flanged hemisphere, dished at the base to fit t mine case.
440. Of what is it made?	Of 15-pound, $\frac{3}{8}$-inch wrought iron.
441. How is it attached to the case?	By the 4 screw bolts projecting from the boss which pass through slots in the flange and held in place by screw nuts keyed down.
442. What is at the pole of the cap?	A hole fitted with a clamp.
443. Is the cap water-tight?	No; water has free access to its chamber.

THE UNITED STATES ARMY MINE—Continued.

THE MINE CASE—Continued.

QUESTION.	ANSWER.
44. What are the uses of the cap?	To clamp the turk's head of the mine cable, to cover and protect the portion of the cable core exposed outside the mine case, and to serve as an attachment for the wire mooring rope.
45. Of what does the mooring attachment consist?	Of a ring of 1½-inch wrought iron, having a clear hole 2½ inches in diameter, attached to the cap by 3 bails of 1-inch wrought iron permanently double riveted to the cap sides.
46. Are the ring and bails one forging?	Yes.
47. What is done to prevent corrosion of the cap and moving attachment?	They are thoroughly galvanized

THE COMPOUND PLUG.

48. What is the type of the circuit closer?	It is of the ball type.
49. How is the cup constructed?	It is of aluminum, contained in a ring of hard rubber.
50. What is in the top of the aluminum cover?	A plate from which are suspended several German silver contact springs.
51. How is the circuit closer secured to the transformer case?	The cup is placed on the upper projecting lip of the case and is held in place by the cover being screwed down tightly over it.
52. What prevents the cup from moving in the cover?	A distance ring of aluminum.
53. What else does this distance ring do?	It secures the contact-spring plate in the top of the cover.
54. To what is the ball cup attached electrically?	One end of the reactance coil.
55. To what is the cover attached electrically?	It is grounded to the compound plug.
56. What is the action of the circuit closer?	When it is tilted to an angle of 45° the ball rolls to one side and makes an electrical contact between the cup and the contact springs.
57. What is the shape of the transformer case?	Cylindrical.
58. What does it contain?	The resistance coil, induction coil, and reactance coil.

THE UNITED STATES ARMY MINE—Continued.

THE COMPOUND PLUG—Continued.

Question.	Answer.
459. What is the resistance coil?	A coil of German silver wire of 2,300 ohms resistance.
460. What is the induction coil?	A "step down" transformer with a primary coil of 100 ohms resistance.
461. What is meant by "step down" transformer?	It transforms a high voltage and low amperage to a lower voltage and a higher amperage.
462. Will a direct current induce a current in this coil?	No.
463. What sort of current must be used to induce a current in it?	An alternating current.
464. What is the reactance coil?	A coil of wire of 100 ohms resistance to a direct current, but practically an insulator to an alternating current.
465. How are these several coils connected?	The resistance coil and primary coil of the induction coil are in series, and the reactance coil and the circuit closer are in series; these two circuits are shunted off from each other.
466. How many exploders are used?	Two.
467. To what are they connected electrically?	To the secondary coil of the induction coil.
468. Where is the transformer secured?	It is screwed into the top of the fuse can.
469. What is the shape of the fuse can?	Cylindrical, with an enlarged base.
470. How are its ends strengthened?	By heavy brass rings soldered in place.
471. How much explosive will the fuse can contain?	About 1 pound.
472. What is the fuse-can cover?	A brass casting, with a stuffing box in a recess in its center, that screws into and closes the bottom of the fuse can.
473. What is the compound-plug union?	A hollow brass casting that connects the fuse-can cover with the compound plug proper.
474. Of what is the compound plug proper made?	Of steel.
475. What is its use?	It screws into and closes the filling hole of the mine case, and bears, on its upper side, the rest of the compound plug, namely and in succession, compound-plug union, fuse-can cover, fuse can, transformer, and circuit closer.

THE UNITED STATES ARMY MINE—Continued.

THE COMPOUND PLUG—Continued.

Question.	Answer.
476. What is in the bottom of the compound plug proper?	A stuffing box.
477. How are the several joints of the compound plug made water-tight?	By lead washers.
478. How are they prevented from unscrewing and working loose.	By set screws.

THE CHARGE.

479. Of what does the charge consist?	Of wet gun cotton or dynamite.
480. What is the weight of the charge when of wet gun cotton?	125 pounds.
481. What is the weight of the charge when of dynamite?	100 pounds.
482. How is the charge held in the mine case?	It is placed loosely in the case and is held against the fuse can simply by its own weight.
483. Of what does the primer consist?	Of 1 pound of either dry gun cotton or dynamite.
484. What are the exploders?	The ordinary commercial electric fuse of double strength, containing 24 grains of mercurial fulminate.
485. How many are used?	Two.
486. Where are they placed?	They are embedded in the primer in the fuse can.

THE GROUND TACKLE.

487. Of what is the mooring line made?	Of the highest grade steel wire rope $\frac{3}{4}$ inch in diameter and well galvanized.
488. How are its ends fitted?	With mooring sockets.
489. What is the shape of the anchor?	Cylindrical.
490. Of what is it made?	Of cast iron.

THE UNITED STATES ARMY MINE—Continued.

THE GROUND TACKLE—Continued.

Question.	Answer.
491. What fittings has it?	2 eyebolts on its upper face.
492. What are they for?	1 for the mooring rope and 1 for the raising rope.
493. How many sizes of anchors are there?	3—1,000, 2,000, and 3,000 pounds.
494. How is the mooring line attached to the anchor ring and to the mooring ring of the mine case?	By shackles, through these rings and through the mooring sockets.
495. What is the raising rope?	A wire rope shackled to the raising ring of the anchor and seized along the single-conductor cable.
496. What is its use?	To lift the anchor by when taking in the mines.

THE DISTRIBUTION BOX.

497. What is the shape of the distribution box?	It is a circular disk-shaped box.
498. What is its diameter?	27 inches.
499. What is its weight?	About 300 pounds.
500. In how many parts is it made?	In 2; a bowl-shaped bottom, 6 inches deep inside, and a slightly curved lid.
501. What is in the center of the lid?	An iron ring, by which the box is raised and lowered.
502. How is the cover fastened to the bottom?	8 pins, fastened to the bottom, fit in corresponding holes in the edges of the cover, and are slotted for keys by which the two parts are fastened together.
503. What are in the vertical edges of the bottom?	20 slots, each about $2\frac{1}{2}$ inches deep.
504. Are these slots all of one size?	No; one is larger than the rest, to receive the multiple cable.
505. What are the others for?	To receive the single conductor cables.
506. What is the use of the distribution box?	All splices between the multiple cable and the single conductor cables are made and insulated in this box.
507. How are the splices insulated?	With rubber or okonite tape.

THE UNITED STATES ARMY MINE—Continued.

THE DISTRIBUTION BOX—Continued.

Question.	Answer.
8. What takes the strain off the splices in the distribution box and at the junction of the single-conductor cable with the mine case?	Turk's heads that engage in the slots of the distribution box or the clamp of the mine cap.
9. How are the turks heads made?	The outer armor wire of the cable is turned back, forming a knob that takes against the sides of the distribution box.
). What are the maneuvering rope and buoy for?	To assist in planting the mine and to plot their position on the plane tables from.
. How is the maneuvering rope made fast to the mine case?	It is rove through the rings on the mine case and buoy and its two ends knotted together so that it can readily be slipped.

THE OPERATING BOARD.

. What is the operating board?	The switchboard from which a set of mines is operated.
. What is the master block?	One section of the board which is common to all the mines of a set.
. What are on the muster block?	The D. C. and A. C. terminals, snap switch, alarm lamp, and alarm bell.
. What is a mine block?	1 section of the operating board which controls 1 mine.
. How many mine blocks are there?	1 for each mine planted, usually 19.
5. What are on the mine block?	The mine switch, feed switch, test switch, breaker switch and coil, and the mine lamp.
5. What is the source of D. C. power?	An ordinary lighting circuit, a generator driven by an oil engine or storage batteries. Usually all three.
5 What is the source of A. C. power?	A small motor generator.
5. Trace the direct current on the operating board with the mine ready to fire.	From the D. C. bus bar to the feed switch, to breaker coil, to test switch, to mine lamp, to breaker switch, to mine switch, through cable to mine.
5. What is the position of all switches on the mine block with the mine ready to fire.	All switches except the test switch are up. The test switch is down.

THE UNITED STATES ARMY MINE—Continued.

THE OPERATING BOARD—Continued.

QUESTION.	ANSWER.
522. Trace the direct current on the operating board after the breaker switch has been thrown.	From D. C. bus bar to feed switch to insulated n- tact in lower arm of breaker switch, to lamp us bar, to alarm lamp and bell (in parallel to ground bar.
523. Trace the alternating current on the operating board after the breaker switch is thrown.	From A. C. bus bar, to lower arm of breaker swi h, to mine switch, through cable to mine.
524. Trace the direct current in the transformer with the circuit closer open.	From mine cable through resistance coil, pri ry circuit of induction coil to ground.
525. Trace the direct current in the transformer with the circuit closer closed.	Through reactance coil and circuit close to ground.
526. Trace the alternating current in transformer.	Through resistance coil and primary circuit o n- duction coil to ground.
527. Why will not the alternating current pass through the reactance coil?	Because it sets up a counter current in this oil that prevents its passing through.
528. What is the use of the test switch?	To test the alarm circuit. It cuts the direct ır- rent off the mine and shunts it through he alarm circuit.
529. What causes the breaker switch to throw when the circuit closer is closed?	The change of the direct current from a circu of high resistance to one of low resistance in he transformer overloads the breaker coil nd causes its armature to fly up and trip the bre ker switch.
530. How may the mine be fired "at will?"	By simply tripping the breaker switch by h d, when the alternating and direct currents ill take the same direction as they would if he breaker switch were thrown by an overload ue to the circuit closer being closed.
531. What indicates that the mine circuit is in good condition?	The mine lamp will be barely incandescent.
532. If the mine lamp were to burn at full candle power, what would it indicate?	That there was a serious ground on the mine ir- cuit, and the breaker switch would throw.
533. What is the voltage of the direct current?	80 volts.
534. What is the voltage of the alternating current?	500 volts at the generator, dropping to 300 vol in the transformer.

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THE UNITED STATES ARMY MINE—Continued.

THE OPERATING BOARD—Continued.

Question.	Answer.
What current fires the exploders?	An induced current in the secondary circuit of the induction coil.
What current induces this current?	The alternating current.
Why does not the direct current induce a current in the secondary circuit?	Because there is no circuit breaker attached to the induction coil.
To what angle is it necessary to tilt the mine for the circuit closer to operate?	45 degrees.
Is the circuit closer adjustable?	No.

PLANTING.

How many mines in a group?	Nineteen.
How far apart are they planted?	100 feet.
What are left between groups?	Narrow channels.
What are these narrow channels for?	For the passage of friendly vessels.
How are these narrow channels defended?	By ground mines.
What is a ground mine?	A mine that lays on the bottom and is fired only by observation.
Is there any limit to the depth of water in which a ground mine would be effective?	Yes; they should never be planted in more than 35 feet of water.
Briefly describe the United States Army ground mine.	It is a hollow mushroom-shaped iron casting, containing 125 pounds of wet gun cotton.
In planting buoyant mines, how many boats are used?	2; the distribution box boat and the planter.
Where is the distribution box boat anchored?	Over the spot where the distribution box is to lay.

THE UNITED STATES ARMY MINE—Continued.

PLANTING—Continued.

Question.	Answer.
550. What has she on board?	The distribution box and the sea end of the mul ple cable.
551. What has the planter on board?	The mines with their ground tackle and the sin conductor cables.
552. How does the end of the single conductor cable get to the distribution box boat?	The planter steams by that boat in the direction the line of mines, and the end of the single cc ductor is passed to her as she goes by.
553. What is done with the end of the single conductor when it is received in the distribution-box boat?	It is immediately spliced to its corresponding cc ductor of the multiple conductor cable.
554. What is the planter doing while this is being done?	Steaming in the direction of the mine's positio in the line of mines, paying out the single co ductor cable.
555. What is done when she crosses this line?	The mine is dropped.
556. How can the mine's position be known?	It has been previously marked by a small buoy.
557. How is the single-conductor cable carried in the planter?	It is coiled down, so as to pay out freely.
558. What is the position of the distribution box in relation to the line of mines?	It is in rear of No. 10 mine, 725 feet away, with t single-conductor cables radiating from it to t mines.
559. Which mines have the longest cables?	Nos. 1 and 19.
560. Which the shortest?	No. 10.
561. Are all the mines dropped in the manner just described?	Yes.
562. How many observation stations are there?	Three.
563. How are they connected with the operating station?	By telephone.
564. How do the observation stations plot the position of the mines on their plane tables?	By observations on the maneuvering buoys befo they are removed.
565. When are the maneuvering buoys removed?	As soon as the observations have been made.

EXPLOSIVES.

CHAPTER X.

EXPLOSIVES.

SMOKELESS POWDER.

QUESTION.	ANSWER.
1. What is an explosive?	A class of bodies, the parts of which are in such an unstable equilibrium that a slight disturbing agency will cause a chemical change among them, the effect of which will produce suddenly a very large volume of expanded gases.
2. What is an explosion?	The result of a chemical change in an explosive by which a volume of highly expanded gas, or gases, is produced.
3. Name an explosive *mixture*.	Ordinary gunpowder (not smokeless).
4. Name some explosive *compounds* used in the Navy.	Guncotton, smokeless powder, fulminate of mercury.
5. What is the meaning of the word *compound* as used above?	An explosive substance in which a chemical change has taken place during its manufacture.
6. How is a *high explosion*, or an explosion of the first order, produced?	A *high explosion* is due to the conversion into gas of the whole mass of an explosive—as by detonation by fulminate of mercury.
7. How is a *low explosion*, or an explosion of the second order produced?	A *low explosion* is due to the explosive being ignited by heat, and converted into gas by gradual combustion.
8. What causes an explosion, and how is it produced?	Heat—either applied directly, as by a match or a hot iron; indirectly, by friction, in which case the mechanical action of rubbing causes heat; by percussion, in which case the heat is generated by a jar, or shock, communicated through a second body.
9. How is "detonation" produced?	"Detonation" is produced by the application of a blow or shock, and is usually accomplished by means of a detonating fuse, containing fulminate of mercury. This produces a violent shock to the explosive, reaching to all parts, and suddenly igniting the same.
10. From what material is gun cotton made?	Weavers', or cop-cotton, waste.
11. What acids are used in its manufacture?	Nitric acid, 1 part, and sulphuric acid, 3 parts

EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

Question.	Answer.
12. Describe briefly the nitrating process.	The dipping troughs are of cast iron, into which the acids are drawn. The cotton is dipped into the mixed acids by means of a steel fork, being well stirred about to prevent a rise in temperature. Cold water circulates outside the dipping trough, which serves to keep the temperature of the acids below 70° F. The dipping occupies about 10 minutes, when the cotton charge is withdrawn from the acids, is placed on a grating and squeezed by a lever press as completely as possible. It is then placed in a digestion pot, which is an ordinary 2-gallon crock of coarse stoneware. It remains thus overnight, with cold water circulating around the outside of the pot to prevent a rise of temperature. The cotton or nitrocellulose, as it should properly be called now, is then put into a centrifugal wringer and then thoroughly and repeatedly washed.
13. State object of, and describe briefly, the pulping and poaching process.	The nitrocellulose, after having passed through the nitration process, contains free acids, and after being washed, as stated in the previous answer, is pulped, which process converts it into a more homogeneous mass. The pulping also facilitates the poaching process, which is a washing process to remove all free acids. The pulper is a wooden vessel, with a cylinder, on which are fixed a number of knife edges; clean water is kept constantly running in this vessel, and as the cylinder revolves the nitrocellulose is forced between the knife edges and the "craw," which is a metal casting on the body of the woodeu vessel. Two days or more are required in the pulping process, and the nitrocellulose is of the consistency of corn mush at the completion of the process. The pulper is elevated above the poacher, into which the nitrocellulose is run by gravity. The poacher is a wooden vessel containing paddles which constantly agitate the nitrocellulose, which is boiled and treated with soda until there is absolutely no trace of free acid, after the heat test, which is applied during the process, and is the guide to determine the completion of the poaching process.
14. How many kinds of gun cotton (nitrocellulose) are there?	Soluble nitrocellulose, which dissolves in ether and alcohol, and insoluble nitrocellulose, which can not be dissolved in ether and alcohol. Nitrocellulose may also be divided into three varieties, to which the following chemical names are given, referring to the amount of nitration (or the amount of nitric acid which has acted upon the cotton), viz, mononitro, binitro, and trinitro cel-

EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

Question.	Answer.
	lulose. The above names are given in their order of strength, i. e., trinitrocellulose has absorbed more nitric acid than binitrocellulose, etc.
Which of the above kinds of nitrocellulose is the stronger, and why?	The insoluble, as it contains more nitric acid than the soluble.
How is gun cotton pressed into blocks or slabs?	The nitrocellulose, after passing the heat test, is emptied from the poacher into a "stuff chest." Here a large proportion of the water is drawn off through tubes, having fine wire-gauze strainers to prevent the nitrocellulose from passing through while hydraulic pressure is being applied. The amount of moisture is carefully calculated now, and the necessary amount of cellulose, by weight, is put into a mold, or former, and pressed into shape by a hydraulic pressure until the block is of the required density.
What is the density of gun cotton as required by naval specifications, and what is meant by the term?	Density, 1.3. This means that 1 cubic inch of gun cotton must weigh 1.3 times as much as 1 cubic inch of distilled water.
Name the different shapes and sizes of gun cotton used in the Navy. Also state what is the use of each.	Blocks and cylinders. Blocks 2.9 by 2.9 by 2 (inches) are used for the charges of naval defense mines, countermines, and wrecking mines. The dry primer blocks for the above are of the same size, with a central perforation $\frac{9}{16}$ inch in diameter. Blocks 8.5 by 8.5 by 2 (inches) are used for the charge of automobile torpedoes. Cylinders 1.11 inches diameter and 2 inches in length, with a central perforation, [illegible] inch in diameter, are used for dry and wet primers of automobile torpedoes.
What percentage of moisture is there in "wet gun cotton?"	25 per cent.
Describe the method of loading a war head with gun cotton.	The blocks of gun cotton, one layer at a time, are placed on a metallic template. The parts of the blocks which project over the template are cut off by a band saw, the proper curvature being given by tilting the table on which the template rests. A spray of cold water is kept playing on the part of the block in immediate contact with the saw. The blocks which pass over the primer case have holes cut in them through which the primer case passes. When the proper number of layers are cut, and are loaded into the war head, the bulkhead is secured in place.

EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

Question.	Answer.
21. Why is it not necessary to keep gun cotton dry in war heads?	Wet gun cotton, when properly detonated, produces as great an explosion as dry gun cotton. The moisture renders it safer to handle.
22. How is gun cotton detonated?	This requires the use of two explosive compounds, viz, fulminate of mercury and dry gun cotton. The fulminate of mercury detonates the dry gun cotton, which is of sufficient power, in exploding, to detonate the wet gun cotton.
23. What use is made of dry gun cotton on board ship?	It is used as dry gun-cotton primers for automobile torpedoes, for naval defense mines, countermines, and wrecking mines.
24. Explain the method of drying primer blocks.	There are two methods, viz, exposure in a steam dryer and exposure in a dry atmosphere. For drying in a steam drier: The drier consists of a suitable vessel, in which there are coils of steam pipes which may be supplied with steam from the steam heating apparatus of the ship, or from some other suitable low-pressure source. The blocks to be dried are weighed separately, and the weight of each is marked on the block with a soft lead pencil. The blocks are then strung on rods, with iron washers between them, and placed in the wire baskets of the drier. The door is closed and steam is turned on. A thermometer indicates the temperature, which must not exceed 100° F. Everything about the drier must be free from all dirt and oil. After each day's heating the blocks are carefully weighed, the weights marked on the blocks, and the drying continued, if necessary. This process is repeated until the blocks no longer lose weight. For drying in the atmosphere, the blocks are strung on a perfectly clean rod, with a space between each block, and exposed to the dry atmosphere. The blocks should be kept in an air-tight vessel when the atmosphere is damp. The blocks are marked and weighed in the same manner as is described for drying in a steam drier. This operation should be carried on in a place remote from galley and other fires. Avoid unnecessary handling of the blocks, as they are apt to flake and crumble.
25. Where are dry primers stowed on board ship?	They are stowed on the upper decks, never below the water line; remote from other explosives and especially remote from those containing fulminate of mercury; no large amount should be stowed in any one place. These primers are contained in glass tubes for convenience of inspection, and so as to permit inspection of the litmus paper which is placed between each block.

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EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

Question.	Answer.
?6. Why are these primers not stowed below the water line?	So as to avoid dampness.
?7. Why are they kept remote from other explosives, and especially from those containing fulminate of mercury?	They are very susceptible to detonation by concussion. Fulminate of mercury will explode them more readily than other explosives.
?8. Describe the method of inspection of dry gun-cotton primers.	Weekly inspection consists of observing the condition of the blocks, or cylinders, of gun cotton, and of the strips of litmus paper placed between them. In the event of any serious decomposition having taken place, the gun cotton will be found more or less covered with yellow spots; the jar or tube will be filled with brownish red, highly acid fumes, and the litmus paper will show a decided change from its original blue to red. Monthly inspection consists of replacing the litmus paper already there with freshly moistened strips of the same.
9. What care should be taken in making these inspections?	Do not handle the gun cotton with the bare hand, but use a clean dry crash towel, and avoid all unnecessary handling. Never touch litmus paper with a bare hand, as the moisture of the hand is acid, but use the forceps supplied for the purpose. Use pure distilled water for moistening the litmus paper, and do not flood it; moisten it only. Always examine the litmus paper in a white light, as it appears reddish in any apartment that is shellacked or colored. Do not mistake iron rust for the above-mentioned yellow spots.
0. How are dry primers packed?	In air-tight jars, contained in wooden boxes with a door, so that they may be readily inspected without disturbing the gun cotton.
1. Why must glass primer jars never be exposed to the sun's rays.	The glass may act as a lens, thereby igniting the contained gun cotton.
2. What is the action of an acid on blue litmus paper?	It turns it red.
3. In inspecting litmus paper, what precaution must be taken?	In addition to those mentioned in answer to question 29, when blue litmus paper is moistened with pure distilled water, it sometimes appears red. A comparative test should be made by moistening two pieces of blue litmus paper, one with pure distilled water and the other with a dilute acid (diluted vinegar). The paper moistened with acid will give the true reaction.

EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

Question.	Answer.
34. Name some defects in gun-cotton blocks which have been wrongly taken for defects from decomposition.	Rust spots, due to rust introduced during manufacture. These rust spots are harmless.
35. Why should gun-cotton blocks be not handled with bare hands.	The blue litmus strips placed between them may turn red from the acid left on the blocks, due to the acid in human perspiration.
36. Explain the process of wetting decomposing gun-cotton primers with the alkaline solution.	Make a saturated solution of carbonate of soda, using pure distilled water, and let the blocks of decomposing gun cotton absorb it to its fullest extent.
37. Name the articles in the "chemical box" and explain their use.	2 forceps for handling litmus paper; 1 pair scissors, for cutting litmus paper; 2 bottles, for distilled water for moistening litmus paper; 2 bottles, for strips of litmus paper; 1 tin cylinder, for keeping ½ quire litmus paper; 2 1-pound bottles of carbonate of soda, for making the alkaline solution; 2 glass rods, for moistening the litmus paper.
38. Describe the method of inspecting wet gun cotton.	All wet gun cotton is weighed quarterly. Each container of wet gun cotton is air and water tight, provided with a moisture cap, which is closed with a screw plug. At the quarterly weighing, should the gun cotton have lost weight, pure distilled water is added to bring it up to standard weight, which is stamped or marked near the moisture tap.
39. From what is smokeless powder made?	Soluble nitrocellulose, dissolved in ether and alcohol, as follows: Soluble nitrocellulose, 33 parts; ether, 22 parts; alcohol, 11 parts.
40. How is soluble nitrocellulose made?	Generally from Tennessee short fiber cotton, picked and absolutely free from grease, dirt, or foreign substances, dipped in a mixture of nitric acid 1 part and sulphuric acid 2 parts for 30 minutes. It is then wrung out and drowned in cold water. Then it passes through the pulping and poaching process, as described for gun cotton.
41. Describe the dehydrating process.	The dehydrator is a double-header hydraulic press. Weigh out a charge of 45 pounds of nitrocellulose, place half of it in the press cylinder, and apply a pressure of 200 pounds; raise the plunger and add the second half of the charge, apply the same pressure, and raise the plunger. Draw into the cylinder, on top of the cake of nitrocellulose, 6 gallons of 95 per cent ethyl alcohol. Air pressure is now admitted near the top of the cylinder at a pressure of 65 pounds per square inch, driving

EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

Question.	Answer.
	out the moisture and some of the alcohol. A hydraulic pressure of 1,000 pounds is next applied. This removes any moisture and the excess of alcohol. The lower plunger is lowered and the block removed, which weighs approximately 47 pounds. The nitrocellulose, before lowering the lower plunger, contains 33 per cent alcohol. The block is now placed in an air-tight zinc cylindrical tank and taken to the mixing house.
2. How is the ether added to the nitrocellulose?	In a mixing machine. This machine is an air-tight vessel provided with revolving knives. A water jacket, in which cold water is kept circulating, prevents rise in temperature and evaporation of ether. When the cake of nitrocellulose is received, it is broken up by hand and dumped into the mixing machine. The knives are revolved for 5 minutes, to break up all large lumps. Then 25 pounds of ether are run in on top of the mass in the mixer, the cover is secured in place, and the knives revolved for two hours, after which it is formed into blocks of 20 ounces in a block press.
3. What is the finishing process?	The 20-ounce blocks are placed in hydraulic presses, which force the blocks through dies into cords or ribbons. These are cut into grains and dried. The pressure used for forcing the blocks through the dies varies from 4,000 to 5,000 pounds per square inch.
4. What is the cause of the black appearance of small-arm powder?	After the grains are formed they are coated with graphite.
5. What is cordite smokeless powder made of?	Nitroglycerin, 58 per cent; gun cotton, 37 per cent; vaseline, 5 per cent.
6. For what is it used in the service?	For the igniter fuse of the superheater of the Bliss-Leavitt torpedo.
7. How is the daily inspection of smokeless powder carried out on board ship?	A sample of each index on board is kept in glass-stoppered bottles, these being kept in the magazines containing the powder, and are given a visual examination daily to note the color and condition of the powder without opening the bottles.
8. How is decomposition of powder detected by this inspection?	Decomposing powder becomes lighter in color, showing a decidedly yellow tinge. This may take place throughout the mass, or only a few grains may be off color.

EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

Question.	Answer.
49. What care should be observed in ascertaining color of powder?	This examination should be made in daylight, possible. Water-dried powder, designated b the letters "S. P. W.," preceding the inde number, is of a light opaque color, owing to th drying process. This must not be confused wit dark-colored powder, off color.
50. How is the fortnightly inspection of smokeless powder carried out?	Open one or more tanks or cases of each index o board, remove a scoopful of powder and exan ine it in a good light as to its color, odor, an physical properties.
51. How is the decomposition of powder detected by this inspection?	Decomposing powder becomes lighter in colo showing a decidedly yellow tinge; nitrous fum are given off, and the grains become in a measu soft, yielding to the pressure of the thumb nai If nitrous fumes are given off, the inside of th box, bag, or tank containing the powder woul probably show a yellowish appearance, and a acrid, pungent odor would be present.
52. How is the monthly test of smokeless powder carried out?	These samples, kept in glass-stoppered bottles be fore referred to, are given a 30-minute litmus te once a month. A strip of litmus paper, moistene with pure distilled water, is suspended in th bottle over the powder for 30 minutes. The lit mus paper is moistened frequently and closel watched for any appearance of a reddish colo which would indicate the presence of acid fume
53. How is the quarterly test of smokeless powder carried out?	The same as in the monthly tests, except that it i of 6 hours' duration.
54. What care should be observed in carrying out a litmus test?	Litmus paper must not be handled with the hands but forceps must be used, which are provided fo that purpose. Use a glass rod with pure dis tilled water, and do not flood the litmus pape when moistening it. Make the inspection i daylight. Do not mistake the bleaching out c the litmus paper for a pink or red color. Make comparative test by dipping a strip of litmu paper in diluted vinegar, and compare it wit another piece moistened with water. The for mer will show the effect acid has on the paper.
55. Why should the samples kept in glass bottles be tested?	Because the conditions of stowage in these bottles which are opened periodically, render it liable t deteriorate more than powder stowed in an air tight tank.
56. How is powder prepared for the heat test?	The grains are thoroughly cleaned by scraping. 2 grains (1.3 grams) are then scraped off with glas or with a scraper. These scrapings are not to b more than 0.002 of an inch in thickness. In th

EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

Question.	Answer.
	case of small-arm powders the samples are to be tested in their original condition. They are then to be dried on watch glasses, at a temperature of 43° C., plus or minus 3° for 48 hours, and then allowed to stand for a sufficient time to take on a proper amount of moisture, which is between 1.5 and 2 per cent. Exposure overnight will be sufficient.
Describe the bath used for the heat test of S. P.	The bath is a copper vessel, having a perforated cover which has supports for holding the test tubes and a perforation for a thermometer.
How is the bath prepared for the heat test.	Fill bath to one-quarter of the top with glycerin or glycerin and water and immerse thermometer, by putting it in its place in the cover, to the same depth as the test-tube holders. Place bath on alcohol or kerosene stove, start burners, and note when thermometer is steady at 65.5° C. It is then ready for the reception of the test tubes containing powder.
Why is glycerin used in the bath?	The consistency of this liquid is less liable to a sudden drop or rise in temperature than water.
What is the test paper used?	It is known as iodide of potassium starch paper.
Give a brief description of its manufacture.	Filter paper is washed in distilled water and dried. It is then put in a mixture of recrystallized potassium iodide solution and starch, and hung in a dark room to dry.
How is this test paper issued to the service?	It is supplied in bottles of black glass, containing 150 strips about ¾ to 1 inch in length and ⅜ inch wide.
What care is observed in handling this paper?	Do not expose it unnecessarily to light. Do not handle it with the bare hands. Do not expose it in any place where acid fumes are present. Keep the supply as new and fresh as is possible.
How does this test paper prove the presence of acid fumes arising from smokeless powder?	By the appearance of a brownish color.
How is the test paper used during a heat test?	It is suspended on a platinum hook on a glass holder which passes through a cork closing the entrance in the test tube. It is moistened at the upper end with a drop of glycerin solution.
Why should not the platinum hook be fastened permanently to the cork?	Because the test paper must be moved in order that the mark of demarcation between the upper (the wet) and the lower (the dry) portions of the test

EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

QUESTION.	ANSWER.
	paper is coincident with the lower edge of a rin of moisture which forms on the inside of the tes tube.
67. What is the composition of the glycerin solution?	One-half chemically pure glycerin and one-hal pure distilled water.
68. Describe the test tubes.	They are glass tubes $\frac{1}{2}$ inch in diameter and $5\frac{1}{5}$ or 5· inches in length.
69. The powder having been scraped, dried, and the necessary amount of moisture absorbed, what is the next step in the heat test?	The samples (20 grains, or 1.3 grams) are placed ir the test tubes.
70. What care should be observed at this stage?	The powder is collected at the bottom of the tube by a gentle pressure of a glass rod, and the side are freed from particles of powder by wiping th sides with a clean piece of toilet or tissue paper
71. Describe the operation of placing the test paper in the tubes.	An incision is made in the test paper in one enc with a clean penknife, and the test paper placec on the platinum-wire holder with the aid of forceps, and the upper end of the test paper is moistened with a drop of the glycerin solution
72. Describe the actual operation of the heat test.	The bath being constant in temperature at 65.5° C., the test tubes containing the powder, with test paper on the holders in place, are immersed in their receptacles in the bath; and the time is noted. If at the end of 40 minutes no discoloration appears on the test paper, it is called a 40-minute test, and the powder is stable. If any discoloration appears on any of the strips of test paper inside of 40 minutes, it is called a minus test and the time of such discoloration should be noted.
73. What other tests of smokeless powder is the iodide of potassium test paper used in?	In a test known as a supplementary test.
74. Describe this test.	The sample of powder, in whole grains, is placed in a glass-stoppered bottle 1 day before the test is to be made. The test consists in placing in the bottle a strip of test paper, 2 inches in length by 1 inch in width, moistened by a large drop of the glycerin solution in a spot about the size of a cent. The paper should remain in the bottle for 1 hour, and no discoloration should appear in that time.

EXPLOSIVES—Continued.

SMOKELESS POWDER—Continued.

QUESTION.	ANSWER.
What are the volatiles in smokeless powder?	Ether, alcohol, and moisture.
What effect does the loss of volatiles have on S. P.?	It causes it to give abnormally high pressures.
Why?	The loss of volatiles represents loss of moisture. This loss causes the powder to burn more quickly, which in turn produces a quicker evolution of gas, thereby simulating a detonation.
State method of obtaining the percentage of volatiles.	One or more samples of grains are selected and cut into slices 0.02 inch in thickness. The first quarter of the length of the grain is rejected. A weighed sample of about 1.2 grams of the slices are thoroughly mixed and heated in an oven for 5 hours at 80° C., when it is again weighed. The per cent of loss represents the relative residual volatiles of the powder.
What is done when the powder fails to stand any test?	It is placed under observation and retested at intervals, not exceeding 1 week, to determine if it is losing its stability. The Bureau of Ordnance is informed at once.
How is it determined whether S. P. is losing its stability or not?	The heat and litmus tests will show a decided falling off. That is, the test papers in each case will show signs of acid reaction in a shorter length of time than the preceding tests.
If repeated tests show no falling off in the litmus and heat tests, what does it signify?	It may be assumed that the powder is serviceable, notwithstanding that the powder fails to give the standard test.
When is powder regarded as unserviceable?	Should the litmus show a decided red tinge in less than 30 minutes, every charge of the index in question being tested, and a heat test of the number of samples of the powder is below 10 minutes, the powder is regarded as unserviceable, and should be landed as soon as possible.
When is decomposing powder regarded as dangerous?	If it is found in a soft or mushy condition it is dangerous and must be thrown overboard immediately.
How is S. P. packed?	In zinc-lined packing boxes, made air-tight. These boxes are marked to show the following information: Index number, manufacturer's lot number, caliber and mark of gun for which intended, weight of charge and character of ignition charge, name of manufacturer, date of manufacture, date of proof.

EXPLOSIVES—Continued.

FULMINATE OF MERCURY.

Question.	Answer.
85. What is the composition of fulminate of mercury?	Nitric acid, 12 parts; alcohol, 11 parts, and mer cury, 1 part.
86. Describe briefly how fulminate of mercury is prepared.	One part of mecury is dissolved in 12 parts o nitric acid, aided by a gentle heat. As soon a the mercury is dissovled, add 11 parts of alcohol A brisk action takes place and the solution wil become turbid from the separation of crystal of the fulminate. Dense white clouds are als evolved at the same time. When the actio has subsided, the vessel may be filled with wate and the fulminate allowed to settle, after whicl it is collected on a filter, washed, and dried b exposure to the air.
87. What are the properties of fulminate of mercury?	It is a very sensitive explosive when dry. It explosive force is not much greater than tha of gunpowder, but it is much more sudden i its action. It explodes by friction or by per cussion, and also by heating it to 300° F., b the electric spark, and by contact with concen trated nitric or sulphuric acid. It will not ex plode while wet. It may be dried after wettin and its explosive force is not lessened.
88. What are the chief uses of fulminate of mercury?	It is used for the explosive substance of percussio caps and friction composition, and for detonat ing high explosives.
89. Describe the appearance of fulminate of mercury.	It is composed of very fine crystals, and if ab solutely pure it is white in color. Most fulmi nate of mercury is, however, of a grayish-brow color.
90. What is the charge of fulminate of mercury used in the service detonator?	35 grains.
91. Describe the service electric detonator.	The stock, or outer tube of brass, has a cap o the same material screwed onto its lower end This tube contains a copper case containing the charge of fulminate of mercury, on top of whicl is placed 4 grains of mealed gun cotton, the whole of which is covered by a wisp of fibrou gun cotton and placed inside the outer tube The detonator legs, or leading wires, the end of which are connected by a platinum bridge are held in place by a plug of ground glass and sulphur, which closes the upper end of the outer tube. The platinum bridge has a wisp of dry cotton around it. The detonator on completion is given a coat of red vermilion paint.

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EXPLOSIVES—Continued.

FULMINATE OF MERCURY—Continued.

Question.	Answer.
2. Why is the wisp of fibrous gun cotton placed upon the top of the explosive in the detonator?	It acts as a protector for the platinum bridge, and as a plug for the copper case which contains the explosive.
3. What is the length and electrical resistance of the platinum bridge in the detonator?	It is $\frac{3}{16}$ inch in length, .002 inch in diameter, and has a resistance of 0.65 ohm, plus or minus 0.03 ohm.
4. Describe the service percussion detonator.	The stock, or outer tube of brass, has a cap of the same material screwed on its lower end. The exterior of this tube is machined to fit in the war nose, and the head contains a recess, in the lower end of which is placed a No. 3 Winchester cap, which has a plunger suspended over it by a shearing flange, prevented from moving by the plunger ferrule. This tube contains a copper case containing the charge of fulminate of mercury, on top of which is placed 4 grains of mealed gun cotton, covered by a wisp of dry fibrous gun cotton.
5. How are detonators stowed on board ship?	They are packed in boxes of tin, painted red, and marked with their contents and the word "dangerous." These boxes have cork linings in the covers over percussion detonators, and are packed and stowed in wooden boxes with sawdust, also marked with their contents and the word "dangerous," also "do not stow below." These boxes must not be stowed below decks, must be stowed in a place remote from dry-primers, and other explosives, and in a place where they will not be subjected to shock from gun fire. If practicable, boxes containing detonators should be separated.
6. What precautions are necessary when using percussion detonators?	Percussion detonators are used only in automobile torpedo war heads. They must, at all times, be handled with the utmost care. They are placed in the holder of the war nose, care being observed that the screw fan is all the way in, and can not be turned in the direction of the arrow marked on the body of the war nose. The war nose containing the detonator is not placed in the war head until positive orders are given to do so.
7. What precautions are necessary when using electric detonators?	Electric detonators must be handled with the utmost care, and after being placed in an explosive the battery ends of the leading wires must be closely watched and guarded, so that they may not be connected to the firing battery until the proper time.

ELECTRICITY.

CHAPTER XI.

ELECTRICITY.

Question.	Answer.
1. What do you understand electricity to be?	An invisible agent which makes itself known to us by various properties, commonly termed *electrical effects* or manifestations.
2. How many kinds of electricity are there, how named and defined?	2—*statical electricity*, which is known as *electricity at rest*, and bodies electrified are said to be *statically charged; current electricity*, which is known as *electricity in motion*.
3. How does statical electricity manifest itself?	A body *statically charged* possesses the power of attracting light bodies to it, and also of attracting or repelling another similarly electrified body.
4. How does current electricity manifest itself?	*Current electricity* produces *magnetism*, which is termed *electro magnetism*.
5. How produce statical electricity?	By rubbing a stick of sealing wax and a piece of fur or a glass rod and a piece of silk together.
6. What is the simplest source of current electricity?	The voltaic cell.
7. Describe a simple voltaic cell.	2 dissimilar metals are partially immersed in acid solution which is capable of acting chemically upon 1 of them more than upon the other when these metals are connected by a wire outside the cell: the combination constitutes a voltaic cell.
8. Explain the action of a simple voltaic cell, using copper and zinc for the two dissimilar metals in dilute sulphuric acid.	Every time the circuit of a cell is completed, and as long as it is completed, the acid attacks the zinc, gradually wasting it away; also the power of the acid to attack the zinc gradually becomes exhausted. Thus a current of electricity will flow from the zinc plate to the copper plate inside the cell and from the copper plate to the zinc plate by the connecting wire outside the cell, and the electrical current is maintained in the connecting wire to perform useful work by the expenditure of so many pounds of zinc and acid inside the cell.
9. What are the plates of a cell?	The *plates* are the elements, metal or carbon, that dip into the *electrolyte*, and are generally referred to as the *electrodes*.
10. What is an electrolyte?	A liquid or dry mixture which acts chemically on the electrodes. In general, it is a liquid that is decomposed by an electric current passing through it.

ELECTRICITY—Continued.

Question.	Answer.
11. What is meant by positive and negative poles?	The poles of a cell are the portions of the metal or carbon plates which project above the electrolyte. In any electro-generative device that pole is considered *positive from which the current flows* and that pole *negative to which the current flows.*
12. What are the terminals of a cell?	Mechanical devices by which the conductors are secured to the plates or poles.
13. What is an anode?	The positive plate or electrode, the one at which the chemical action is the greater, and is the plate by which the current enters the liquid.
14. What is a cathode?	The negative plate or electrode, and is the one by which the current leaves the liquid.
15. Where are the positive and negative poles of a cell?	The positive pole and terminal is on the negative plate, and the negative pole and terminal is on the positive plate.
16. Give the table of electro-chemical series.	1. Aluminium. 2. Manganese. 3. Zinc. 4. Iron. 5. Nickel. 6. Lead. 7. Tin. 8. Copper. 9. Hydrogen. 10. Mercury. 11. Silver. 12. Gold. 13. Platinum. 14. Carbon. 15. Chlorine. 16. Oxygen.
17. What is meant by this series?	Commencing with No. 1 each substance below it is electro-negative to the one above it—viz, aluminium is electro-positive to any substance below it and if used in a cell with any of the other substances aluminium would be the positive plate.
18. Which is the negative electrode in a lead-copper cell?	The copper plate.
19. Which is the positive plate in a lead-iron cell?	The iron plate.
20. What is polarization?	When the circuit of a cell is closed, the electric current passing from the positive plate deposits bubbles of hydrogen on the negative plate which in time coats it with a film of hydrogen. Hydrogen is positive to zinc and a reversal of electromotive force takes place inside the cell, thus weakening the current in the external circuit.
21. What means are used to overcome polarization?	Chemically—by putting in some substance that has an excess of oxygen in it. The hydrogen which causes polarization unites with the oxygen, forming water.

ELECTRICITY—Continued.

Question.	Answer.
	Mechanically—by having a rough and broken surface at the negative plate. The bubbles of hydrogen then collect on the angles and corners and rise to the surface as soon as the circuit is broken.
2. What is meant by local action in a cell?	Ordinary zinc contains many impurities, such as small particles of carbon, iron, tin, lead, etc., and when placed in a cell these foreign particles form numerous local voltaic cells on the surface of the zinc inside the cell, with the result that the zinc is being continuously eaten away, whether the cell is in action or at rest. These currents divert just so much strength from the regular battery current, thereby weakening it.
3. How prevent local action?	By coating the zinc plate with mercury.
4. What is an ampere?	The unit of current, or the rate of flow of current. It is sometimes referred to as the intensity of current.
5. What is a volt?	The unit of electro-motive force, or E. M. F., as it is called. Electro-motive force is the force urging on the electricity. It arises from the difference of electrical level between any two points which are joined by a conductor along which a current is flowing.
6. What is meant by "difference of potential?"	The difference of electrical pressure between two points on a circuit, causing a current of electricity to flow from the point of high potential to the point of low potential. Difference of potential is closely connected with E. M. F. The word potential as used in an electrical sense is analogous to pressure in gases, head in liquids, and temperature in heat.
7. What is an ohm?	The unit of resistance. A conductor has 1-ohm resistance when a steady E. M. F. of 1 volt applied to it produces 1 ampere of current, or a current of 1 ampere will flow in a conductor of 1-ohm resistance if there is a difference of potential of 1 volt between the terminals.
8. What is meant by resistance?	That which retards or resists the flow of current along a conductor. All substances offer more or less resistance to the flow of electricity.
9. What is a mho?	The unit of conductivity, and is the opposite of the ohm. It is the conductivity of a conductor whose resistance is 1 ohm.
0. What is meant by conductivity?	The ease with which substances conduct electricity. Conductivity is the opposite to resistance.

ELECTRICITY—Continued.

QUESTION.	ANSWER.
31. What is a watt?	The unit of power, or rate of doing work. On watt = 1 volt × 1 ampere.
32. How many watts to 1 horsepower.	746 watts equal 1 horsepower.
33. What is a kilowatt?	1,000 watts equal 1 kilowatt.
34. What is a coulomb?	The unit of quantity of electricity. 1 coulomb o electricity is conveyed by 1 ampere of current i 1 second of time, and is sometimes referred to a the ampere second.
35. What is a joule?	The unit of work. It is sometimes referred to as th unit of heat, as heat and work are mutually con vertible. One joule a unit of work expressed a heat is developed in a conductor in 1 second o time by a current of 1 ampere flowing through a resistance of 1 ohm.
36. What is a farad?	The unit of capacity. A condenser has a capacity of 1 farad when a coulomb would charge it to a potential of 1 volt.
37. What is a microfarad?	$\frac{1}{1000000}$ of a farad.
38. What is a henry?	The unit of self-induction. It is the induction in a circuit when the induced E. M. F. is 1 volt when the inducing current varies at the rate of 1 am pere a second.
39. From whom did the unit "henry" receive its name?	After "Joseph Henry," an American physicist who discovered many of the laws of electro-magnetic induction.
40. What similarities exist between the flow of electricity along a conductor and its causes and those of a flow of water through a pipe?	If 2 vessels partially filled with water are connected by a pipe, and placed at the same level, there will be no *current* of water, because the pressure at each end is the same. When one vessel is raised above the other there is a *difference of pressure* between the two ends of the pipe, and a *current of water* will flow from the *higher* to the *lower* level, due to the *difference of pressure*. Now a *current of electricity* will not flow along a conductor unless there is a *difference of potential* corresponding to the *difference of pressure* of the water in the ends of the pipe, so this *pressure* corresponds to the *difference of potential*, or E. M. F., and expressed by the *electrical units* as so many *volts*. The *current of water* passing through the *pipe* corresponds to the *current of electricity* passing along the *conductor* and expressed by *electrical units* as so many *amperes*. The *quantity of water* delivered from the higher vessel to the lower vessel corresponds

ELECTRICITY—Continued.

Question.	Answer.
	to the *quantity of electricity*, expressed by *electrical units* as so many *coulombs*. The friction the *water* meets with passing through the *pipe* corresponds to the *resistance* met by the *current of electricity* along its *conductor*, expressed by electrical units as so many *ohms*.
41. What is ohms law?	In any circuit through which a current is flowing we have the 3 following factors present: (1) The *pressure* or potential difference, expressed in *volts*, causing the current to flow; (2) the opposition or *resistance* of the circuit, expressed in *ohms*, which must be overcome before the current can flow; (3) the *current strength*, expressed in *amperes*, which is maintained in the circuit, as a result of the pressure overcoming the resistance. A definite and exact relation exists between these 3 factors—*pressure*, *current strength*, and *resistance*. The *current strength* in any circuit is equal to the *electro-motive force* applied to the circuit, divided by the *resistance*. Thus the value of any 1 factor may be calculated if the values of the other 2 factors are known.
42. What is the formula for ohms law?	$\text{Current}=\frac{\text{pressure}}{\text{resistance}}$ or $\text{amperes}=\frac{\text{volts}}{\text{ohms}}$ or $C=\frac{E}{R}$. Let E=E. M. F., potential difference or available pressure, in volts, applied to any circuit; R=resistance of circuit expressed in ohms; C=current strength expressed in amperes; Pressure=current strength × resistance; Or Volts=amperes × ohms; Or $E=C\times R$. $\text{Resistance}=\frac{\text{pressure}}{\text{current strength}}$ Or $\text{Ohms}=\frac{\text{volts}}{\text{amperes}}$. Or $R=\frac{E}{C}$.
43. What is meant by a conductor?	Any substance which offers small resistance to the passage of an electric current.
44. Name some good conductors in their order of conductivity.	Silver. Copper. Aluminum. Zinc. Platinum. Iron. Lead. Mercury. Carbon. Water. German silver. Platinum silver. Manganese. Brass. Bronze. Phosphor bronze.

ELECTRICITY—Continued.

Question.	Answer.
45. Name some partial conductors.	The body. Cotton. Dry wood. Paper.
46. What does the resistance of a conductor depend on?	The material, length, diameter, and cross section.
47. What is the relation between the resistance and the conductivity of a conductor?	As the resistance increases the conductivity decreases.
48. What is the rule for figuring the resistance of a wire, as regards their length and cross section.	The resistance of any wire is equal to its length multiplied by the resistance of a mil-foot and this product divided by its area.
49. How does cross - sectional area of wire affect the resistance?	The resistance of a conductor is inversely proportional to its cross-sectional area, and in the case of round wire inversely proportional to the square of the diameter. A wire ½ inch in diameter has four times as great a resistance as wire 1 inch in diameter, because as the area increases the resistance decreases.
50. What effect does heat have on the resistance of wire?	All metals have their resistance increased by an increase of temperature.
51. Name some substances that an increase of heat decreases their resistance.	Carbon and all electrolytic conductors decrease in resistance as the temperature increases.
52. What is the unit of area in the calculation of round wires for electrical purposes?	The circular mil.
53. What is a circular mil?	A mil is 0.001 inch. The area of a round wire 1 mil in diameter is 1 circular mil.
54. What is meant by a nonconductor or insulator?	A substance the resistance of which is so high, the *conductivity* so poor, it is classed as a poor *conductor*, which ranks the substance as a good *insulator*. The property of an insulator is to obstruct the flow of current.
55. Name some nonconductors or insulators.	Oils. Shellac. Varnish. Porcelain. Wool. Silk. Rubber. Cotton. Resin. Mica. Paraffin. Ebonite. Glass. Air.
56. What general classes are cells for producing electricity divided into?	Open-circuit cells, and closed-circuit cells.

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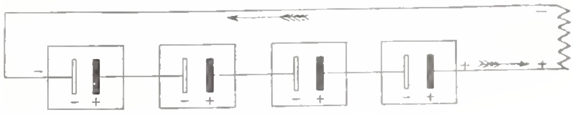
ELECTRICITY—Continued.

Question.	Answer.
. What is meant by open-circuit cells?	In cells of this class polarization does not have much opportunity to occur, since the circuit is closed for such a short period of time, hence these cells are ready to deliver a strong current when used intermittently. If kept in continuous service for any length of time the cell becomes polarized or run down, but will recuperate after remaining on open circuit for some little time.
. What are open-circuit cells used for?	For intermittent work, where the cell is in service for short periods of time, such as in electric bell and annunciator work, for firing primers or detonators, etc.
. What is meant by closed-circuit cells?	A cell in which polarization is prevented by chemical action, so that the current will be constant and steady until the energy of the chemicals or positive element is consumed or expended.
. Name cells in common use in the Navy.	The Leclanche Gonda cell and several forms of dry cells.
. Give a brief description of the Leclanche Gonda cell.	Is of the single solution type, open-circuit class, with a depolarizer consisting of 2 compressed slabs of manganese surrounding the negative element, which is carbon, the positive element being zinc. The electrolyte is a strong solution of ammonium chloride, commonly known as sal ammoniac. E. M. F. about 1.48 volts and an internal resistance of about 0.4 ohm.
. How set up a Leclanche Gonda cell?	Place in a quart glass jar 6 ounces of sal ammoniac; pour in water until jar is $\frac{1}{3}$ full, and stir thoroughly. Insert positive and negative elements, and set cell away, without connecting up, for a short space of time, to allow the liquid to dissolve the sal ammoniac. The cell is then ready for use. Add water to replace loss by evaporation when necessary, and keep jar about $\frac{2}{3}$ full.
. What are Leclanche cells used for on board ship?	For general bell work.
. What care should be observed with Leclanche Gonda cells?	Keep the cells clean, free from accumulation of salts on the electrodes, and take precautions to keep liquid from splashing over as the ship rolls. The battery locker should be kept free from dust and be in a cool, dry location. Above all, it should be seen that there are no short circuits when the circuit is open.
. Give a brief description of a dry cell.	The cell itself forms the anode, being made of zinc to which is soldered the terminal. The cathode, or negative element, is a carbon slab embedded in a paste which fills the cell. Next

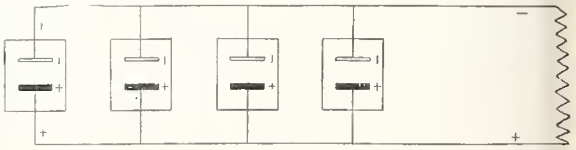
ELECTRICITY—Continued.

QUESTION.	ANSWER.
	zinc cup is a layer of powdered ammonium chlo ride mixed with lime, inside of which is a pow dered mixture of graphite and manganese diox ide, in which the carbon is embedded in the cen ter of the cell. The carbon projects over the to of the zinc cup or cell and has a terminal at it upper end. The cell is sealed with pitch, t prevent the access of moisture and for mechani cal protection. E. M. F., 1.5 volts; interna resistance of small cell, 0.3 ohm; of large cell 0.15 ohm.
66. What are dry cells used for in the Navy?	For firing guns and torpedoes, for detonating ex plosives, illuminating night sights of guns, etc.
67. What care should be observed with dry cells?	That no cell becomes short circuited, that they b not allowed to stand long on closed circuit, an that they are kept in a cool, dry place.
68. Give a brief description of a gravity Daniell cell.	Is of the 2-fluid type, closed-circuit class. Th liquids are kept apart by gravity, one liqui floating on top of the other. Zinc in the shap of a crow's-foot is the positive element and i supported on the edge of a glass jar, the crow's foot immersed in zinc sulphate, which, being th lighter liquid, floats on top of copper sulphate i which the copper plate is situated at the botton of the jar, and from the copper plate an insulate wire leads to the surface and forms the positiv pole. Crystals of copper sulphate are kept i the liquid.
69. How set up a gravity Daniell cell?	Insert positive and negative elements, put in crys tals of copper sulphate (bluestone), fill jar wit pure water, and short-circuit cell. The resistanc is high at the start but gradually diminishes a zinc sulphate is formed. The dissolved zin forms sulphate of zinc, which floats on top of th copper sulphate. The copper in the solutio which is displaced by the zinc is deposited upo the copper plate. Crystals of sulphate of coppe are kept in the solution to keep up the supply c copper which is being deposited upon the coppe plate. This cell will not polarize; all that i necessary to keep a constant current of about volt per cell is to keep up the supply of sulphat of copper crystals and replace the zinc elemen when worn out.
70. Can a Daniell gravity cell be used on board ship?	No; because the rolling of the ship would mix th 2 fluids.
71. How make an improvised cell?	By inserting a zinc and a copper plate in a buck of salt water.
72 Upon what does the current of a cell depend?	The internal resistance.

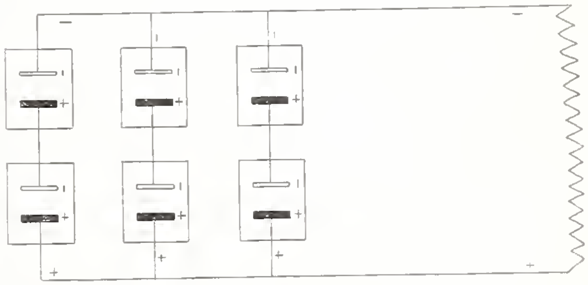
ELECTRICITY—Continued.

Question.	Answer.
73. Upon what does the internal resistance depend?	The submerged area and the distance apart of the positive and negative elements and the character of the electrolyte used. The larger the area of the plates and the closer together they are placed in the cell the less will be the internal resistance.
74. Upon what does the E. M. F. of a cell depend?	The chemical action of salts or acid upon on[illegible]al more than another, the greater the difference in intensity of chemical action the greater the difference of potential and the greater the electromotive force which depends upon the difference of potential. The E. M. F., or voltage of a cell, is independent of size or distance apart of plates.
75. Would you expect a very large cell to have the same E. M. F. as a smaller cell of the same kind?	Yes. See answer to previous question, No. 74. The larger cell would, however, maintain a current longer than the same cell with the same E. M. F. or voltage. The current or amperage is increased or decreased with size of cell, but always with the same E. M. F.
76. What are primary batteries?	A group of two or more primary cells properly connected together constitute a primary battery.
77. Are primary batteries used to develop power? Why?	No. They do not supply enough E. M. F. with amperage for their size and weight.
78. What advantages can be obtained in having a number of cells connected together as a battery, instead of having 1 very large cell.	A number of cells may be so connected as to give different results for various purposes. A large cell has no greater pressure (E. M. F. or voltage) than a smaller one of the same kind. Two smaller ones of the same kind can, however, be connected to give twice the pressure (E. M. F. or voltage) of the larger one. (See answer to questions Nos. 74 and 75.)
79. How connect cells to increase the E. M. F. (for pressure or voltage)?	In series. By connecting the positive pole of one cell to the negative pole of the next, etc.
80. Explain how the E. M. F. is increased.	The cells so connected exert their pressure (E. M. F. or volts) in the same direction, consequently the total pressure (neglecting the internal resistance) is the sum of all pressures of cells connected in series.
81. Draw figure of battery of cells connected in series.	

ELECTRICITY—Continued.

Question.	Answer.
82. Each of the above cells have an E. M. F. of 1.5 volts, an internal resistance of 0.4 ohm and a resistance of 4 ohms in the external circuit. What is the current in amperes? Explain method of calculating.	Find the total E. M. F. applied by multiplying the E. M. F. of 1 cell by the number connected in series. Find the total internal resistance by multiplying the internal resistance of 1 cell by the number of cells in series. Then by Ohm's law the E. M. F. divided by the resistance equals the current. Let E.=E. M. F. of 1 cell. r=internal resistance of 1 cell; ns=number of cells in series; R=external resistance; C=current in amperes. Then $C=\frac{E\times ns}{r\times ns+R}$ or $\frac{1.5\times4=6}{.4\times4+4=5.6}=1.071$ amperes. Thence a current of 1.071 amperes will flow in the external circuit with an E. M. F. of 6 volts through a total resistance of 5.6 ohms.
83. Why multiply the internal resistance of 1 cell by the number of cells in series?	Because the current passes from 1 cell through the next cell and so on through the entire battery, thereby increasing the internal resistance.
84. Why multiply the E. M. F. of 1 cell by the number of cells connected in series?	See answer to question No. 80.
85. What are the advantages of a series grouping?	A series grouping is employed when the external resistance is the principal thing to overcome and the maximum current strength is desired in the circuit.
86. How connect cells to increase amperage?	In parallel or multiple, by connecting all positive terminals to the positive wire of the external circuit and all negative terminals to the negative wire of the external circuit.
87. Explain how the current is increased.	The current depends upon the size of the elements used. (See answer to question No. 75.) By connecting cells in parallel it has the effect of a single cell with elements or plates as large in area as the combined area of the elements in all the cells so connected.
88. Draw figure of a battery of cells connected in parallel.	

ELECTRICITY—Continued.

Question.	Answer.
89. Each of the above cells have an E. M. F. of 1.5 volts, an internal resistance of 0.4 ohm, and a resistance of 0.4 ohm in the external circuit. What is the current in amperes? Explain method of calculating.	The E. M. F. of a battery connected in parallel is the same as that of 1 cell. Find the total internal resistance by dividing the resistance of 1 cell by the number of cells connected in parallel. Add the external resistance. Then, by Ohm's law, the current equals the E. M. F. divided by the total resistance. Let E=E. M. F. of 1 cell; r=internal resistance of 1 cell; nq=number of cells in parallel; $\frac{r}{nq}$=total internal resistance of cells in parallel; R=total external resistance; C=current in amperes: Then $C=\frac{E}{\frac{r}{q}+R}$ or $\frac{1.5}{\frac{0.4}{4}+0.4}=0.5=3$ amperes. Hence a current of 3 amperes will flow with an E. M. F. of 1.5 volts through a total resistance of 0.5 ohm.
90. Why divide the resistance of 1 cell by the number of cells in parallel?	Because the current does not have to flow through each cell in turn as in series grouping, there being a path for the current to flow from each cell in parallel. See also questions and answers Nos. 72, 73, and 86.
91. Why not multiply the E. M. F. of 1 cell by the number of cells in parallel?	See questions and answers Nos. 72, 73, and 75.
92. What are the advantages of parallel grouping?	Cells are connected in parallel when it is desired to obtain the maximum current through a low external resistance circuit or when a small current is required for a long period of time. When so arranged the cells are equivalent to 1 large cell, and will give a large quantity of electricity.
93. Draw figure of a battery of cells connected in multiple series or multiple arc.	
94. Having the E. M. F. and the internal resistance of each cell, how calculate the current from a multiple series grouping of cells?	We have in the figure 3 groups of 2 cells in series. Compute the E. M. F. and internal resistance of 1 group by Ohm's law. Consider the results as the data for 1 cell and then make calculations for the number of such cells (groups) arranged in parallel.

ELECTRICITY—Continued.

Question.	Answer.
95. What are the advantages of a multiple-series grouping?	Multiple-series grouping, being a combination of series and parallel grouping, may be used to advantage to give the maximum current through an external resistance or to increase the capacity of the cells for maintaining a current in a circuit for a long period of time.
96. Would you connect 2 cells in parallel having an E. M. F. of 0.7 and 2.4 volts, respectively.	No; as the low-voltage cell would short-circuit the current and no current would flow in the external circuit.
97. How connect cells for firing batteries? Why?	In series. 0.6 of an ampere of current is required to fire a primer. This current has, however, to overcome a high resistance in the circuit. The cells are so connected to increase the voltage to overcome this high resistance.
98. Describe the service gun firing battery.	Consists of 4 or 6 rectangular 3 by 4 by 7 inch dry battery cells. E. M. F. of each cell 1.5 volts, with an internal resistance of 0.15 ohm. The cells are connected in series and placed in a wooden box, which in turn is protected by a galvanized-iron box, the cover of which is removable and provided with a rubber gasket. Suitable terminals on the outside of box provide ready means for attaching firing circuit or night-sight illuminating circuit.
99. Describe the service naval defense mine firing battery.	Consists of 4 cylindrical 3-inch diameter by 6-inch long dry battery cells, connected in series. E. M. F. of each cell 1.5 volts, with an internal resistance of 0.2 to 0.3 ohm. These cells are placed in a cast brass battery box on top of strips of wood; cardboard surrounds them, preventing contact of cells with battery box. One terminal of battery is grounded to metal of box, the other leads to insulated and water-tight terminal in cover of box. Melted pitch is then poured into box, completely filling space between and covering cells. The cover of box is then bolted in place against a rubber washer, making battery box perfectly air and water tight.
100. Describe the service wrecking mine battery.	Consists of 6 cylindrical dry battery cells (same as cells for naval defense mine firing battery) connected in series, placed in a wooden box with hinged lid and provided with a handle for convenience in carrying. Each cell is prevented from touching the next by light wooden battens, and the leading wires from wrecking mine, with a firing key in series, are attached to battery to positive and negative terminals of end cells in series. The box is marked "Wrecking outfit firing battery."

ELECTRICITY—Continued.

QUESTION.	ANSWER.
01. Describe the service countermine firing battery.	Consists of 50 cylindrical dry battery cells (same as cells for naval defense mine firing battery) connected in series, placed in a wooden box with a hinged lid. The cells are placed side by side in the box and are not connected in series until about to be used. Two or 3 boxes of 50 cells each are used at each end of the line of countermine battery leading wires. Great care must be observed in connecting batteries at each end of the line to have the same pole at each end connected to the main cable of the line.
02. A gun-firing circuit has a resistance of 0.5 ohm. The resistance of a primer being 0.65 ohm, and it requires 0.6 of an ampere of current to fire the primer, what voltage is necessary? Explain method of calculating.	Per Ohm's law: $E=C\times R$. or $0.6\times 1.15=0.69$ volts. If $C=0.6$ ampere of current required. $R=0.5$ ohm in firing circuit plus 0.65 ohm on primer=1.15 ohms. Then $E=0.69$ volts, the voltage required.

SECONDARY BATTERIES.

03. What is a secondary battery?	An electric storage battery or accumulator and is a combination of cells, each of which is a unit. They consist of certain materials so arranged that when they have undergone chemical action due to a current of electricity the combination has acquired the property of a voltaic cell, and is enabled to discharge into a closed circuit a current of electricity approximately the same as the original charging current.
04. Describe a secondary cell.	Consists of a hard rubber, glass, or lead-lined vessel which contains the plates or grids, suspended and immersed in a solution of sulphuric acid called "electrolyte." The plates 9 positive and 9 negative are of lead, and both contain oxide paste forced into the grids or openings in them. The positive plate is hard lead and is of a brown or deep red color. The negative plate is a softer lead and is of a slatey gray color. The plates are separated one from the other by strip insulators and are placed so that each negative plate has a positive plate on each side of it. All positive plates are connected together above the cell, and all negative plates likewise connected.
05. Do secondary cells store electricity?	No. But a chemical reaction takes place by passing an electric current through a secondary cell from one plate to the other by way of the electrolyte, which makes one plate of a higher potential than the other.

ELECTRICITY—Continued.

SECONDARY BATTERIES—Continued.

Question.	Answer.
106. What similarity exists between a primary cell and a secondary cell?	A primary cell not run down is the same as a secondary cell charged. A secondary cell discharged is the same as a primary cell run down.
107. Describe the action of a secondary cell in charging.	A current of electricity is passed through the cell. This current decomposes the electrolyte, causing a transference from the plate where the current enters, depositing the material from it, in the form of peroxide of lead, on the other plate, which makes the latter of a higher potential.
108. Describe the action of a secondary cell in discharging.	Current flows from the plates of highest potential to the plates of lowest potential, causing an electric current to flow in the external circuit when same is closed until the plates have regained their original condition.
109. Explain the use of the terms "positive" and "negative" in speaking of the plates of a secondary cell.	It is customary to call that plate positive at which the current enters the cell, when charging, and from which the current leaves the cell when discharging; the other plate is called the negative plate.
110. Describe a secondary battery (accumulator or storage battery).	Consists of a number of secondary cells connected together as follows: The positive plates of one cell are connected to the negative plates of the next cell by connecting strips.
111. What is the meaning of the term "gassing?" To what is it due?	If the charging current is continued when all the active material is converted and the cell or battery is fully charged no further effect will be produced, except to continue to decompose the electrolyte, the resulting gases passing off through the electrolyte, giving it a milky appearance.
112. What is the meaning of the term "sulphated?" To what is it due?	If the cell or battery is discharged and left to stand with the electrolyte in place sulphating takes place. This means that a white insoluble sulphate which has a higher proportion of lead is deposited on the plates; this sulphate is a nonconductor, and must be removed by mechanical means, and when so removed carries some of the active material with it.
113. How is sulphating avoided?	Do not completely discharge a cell or battery. If not to be used for some time see that cells are charged.
114. What is the meaning of the term "buckling?" To what is it due?	If a cell is discharged below 1.9 volts sulphating is liable to occur, which leads to the distortion of the positive plate. This is known as "buckling," the cause of which is the formation of sulphate in the plugs of active material which fill the spaces of the grids, thus causing the plugs to expand, the

ELECTRICITY—Continued.

SECONDARY BATTERIES—Continued.

Question.	Answer.
	plate being forced out of shape. As the plates are located close together, buckling is liable to cause the plates to come in contact with each other, and short-circuit the cell. Discharging the cells at too high a rate of discharge also causes buckling, due to the chemical action going on too rapidly; the insoluble sulphate is formed in the active material of the positive plate, causing disintegration of the active material and consequent buckling.
115. How are secondary batteries rated?	At a certain number of ampere hours.
116. What is an ampere hour?	1 ampere of current times 1 hour of time.
117. Upon what does an ampere hour depend?	The weight of the surface area of the active material in the cell.
118. What care should be observed in discharging a secondary battery?	A certain economical discharge rate depending on the surface area of the plates exposed to the electrolyte should not be exceeded. (See answer to question No. 114.)
119. What care should be observed in charging a secondary battery?	Charge at the same rate as a cell should be normally discharged or preferably at a slower rate, continued at a proportionately longer time.
120. For what purposes are storage batteries used in the Navy?	(*a*) As motive power for submarine vessels when the gasoline engines can not be used, viz, when they are submerged. (*b*) For the motive power of some service launches. (*c*) For supplying the necessary current for isolated wireless stations which can not be supplied by dynamos.

MAGNETISM.

121. What is a natural magnet?	A stone having oxide of iron in it.
122. What important properties does a natural magnet possess?	It will attract small pieces of iron and steel to it. If suspended freely by a string it possesses the property of pointing always in a particular direction. A third important property possessed by a natural magnet is that of imparting its properties to a piece of hard iron or steel when touched to it without apparently losing any of its original force, thus converting the piece of steel or iron into an "artificial magnet."

ELECTRICITY—Continued.

MAGNETISM—Continued.

Question.	Answer.
123. Define a magnet.	A magnet is a piece of steel, or other magnetized substance, which possesses the properties of attracting other pieces of steel or magnetizable bodies to it, and of pointing, when freely suspended in a horizontal position, toward the north pole of the earth.
124. What are the poles of a magnet?	The ends of a magnet or where the magnetism is greatest are termed the poles.
125. What is the neutral point of a magnet?	A point midway between the poles of a magnet is neutral, and has no power of attraction or repulsion.
126. What is meant by bipolar and multipolar magnets?	A bipolar magnet has two poles. A multipolar magnet has 4, 6, or more poles, but always a multiple of two.
127. How are the poles of a magnet named?	If a magnet is freely suspended, the end which points toward the north geographical pole is called the north pole, while the other is called the south pole.
128. What is meant by the term "polarity?"	It refers to the nature of the magnetism at a particular point; that is, whether it is north or south, seeking magnetism.
129. What is the "law of magnetic attraction and repulsion?"	Like poles repel each other. Unlike poles attract each other.
130. What is the distinction between magnets and magnetic substances?	A magnet attracts only at its poles, each of which possesses opposite properties. A magnetic substance will be attracted to a magnet no matter what part of it is approached to the magnet; a magnetic substance does not possess fixed poles or a neutral point, while a magnet has at least two poles, one of which always repels or attracts one pole of another magnet.
131. Name the most common magnetizable metals.	Steel and iron.
132. How make a magnet?	(1) By rubbing a piece of steel or iron with a magnet. (2) By sending a current of electricity around a piece of steel or iron, through a number of turns of insulated wire, the iron or steel will be magnetized.
133. How may magnets be classed?	As natural magnets or lodestone and artificial magnets.

ELECTRICITY—Continued.

MAGNETISM—Continued.

Question.	Answer.
134. How may artificial magnets be classed?	As permanent or temporary magnets.
135. What is a permanent magnet?	A certain quality of steel once magnetized retains its magnetism permanently to a certain extent after magnetization.
136. What are temporary magnets?	Soft iron under the influence of a permanent magnet, or soft iron under the magnetic influence of a current of electricity passing near it.
137. What is magnetic force?	The force exerted by one magnet on another to attract or repel it, or to attract iron filings or pieces of iron, is termed magnetic force.
138. What are lines of force?	Are imaginary lines emanating in all directions from a magnet, which by their direction show the resultant of the magnetic force, and by their number the magnitude of the force.
139. What is a magnetic field?	The space which is permeated by the magnetic lines of force surrounding a magnet is called the magnetic field.
140. What is meant by magnetic flux?	It is the flow of magnetic lines of force from one pole to another.
141. How prove the existence of magnetic lines of force in a magnetic field?	By covering a magnet with a piece of paper and sprinkling iron filings on the paper while gently tapping its edge. The filings, being magnetic bodies, arrange themselves in the direction of the magnetic curves or lines of force and thus produce a graphical representation of the magnetic field surrounding the magnet.
142. Define magnetic permeability.	The capability of any substance for conducting magnetic lines of force is termed its permeability.
143. What is reluctance?	The resistance to the magnetic lines of force in a magnetic circuit is termed its reluctance.
144. What are the conditions of soft iron as regards magnetism compared with those of hard steel?	Soft iron is more readily magnetized; that is, its permeability is greater than steel. Soft iron loses its magnetism in a great measure when the magnetizing influence is removed. Steel, on the other hand, is harder to magnetize; that is, its reluctance is greater than iron, but it is said to retain its magnetism permanently.
145. How can a magnetized piece of steel be freed from its magnetism?	By imparting to it a sharp blow or by heating it to a red heat.

ELECTRICITY—Continued.

MAGNETISM—Continued.

Question.	Answer.
146. What is meant by magnetic saturation?	Magnetic saturation refers to the utmost capacity for receiving magnetism.
147. What is a horseshoe magnet?	A bar of steel bent into the form of a horseshoe and then properly magnetized is called a horseshoe magnet.
148. How make a horseshoe magnet?	After bending a steel bar into horseshoe shape, wind each limb with an insulated wire. Each limb must be wound in the opposite direction to the other. Send a strong current of electricity through the wire from a battery or dynamo. The horseshoe will become permanently magnetized, with a north and south pole.
149. Why is a horseshoe magnet stronger than a bar magnet?	Because in a bar magnet only one pole could be used at a time, while in a horseshoe magnet both poles act together.
150. What is a laminated or compound horseshoe magnet?	It is built up of a number of separate horseshoe magnets and fastened together with their like poles at the same end.
151. What are compound or laminated horseshoe magnets used for?	In electrical measuring instruments, magneto-electro-generators, and in telephones, etc.
152. What kind of magnets are used in a compass?	Permanent bar magnets.
153. What is an electro-magnet?	A piece of iron around which an insulated wire is wound carrying an electric current becomes strongly magnetized while the current flows, and is called an electro-magnet.
154. How construct a horseshoe electro-magnet?	Bend a piece of soft iron into a U or horseshoe shape. An insulated wire may be wound directly upon the limbs of the horseshoe, one limb in one direction and the other in the opposite direction. It is customary, however, to wind the insulated wire upon wooden or brass bobbins or spools several layers deep, which are then slipped over the soft iron horseshoe cores. The spools are then connected by wire, so that the current will flow around each spool in the opposite direction as viewed from the end of the core, when the limbs will have opposite polarity.
155. What are the principal uses of horseshoe electro-magnets?	To create the magnetic field of bipolar dynamos, to interrupt direct current, to vibrate electric bells, to operate valves of electric whistles, for telegraph relays and sounders, etc.

ELECTRICITY—Continued.

MAGNETISM—Continued.

Question.	Answer.
156. Name some other forms of electro-magnets.	Multipolar field rings for dynamos, laminated cores of armatures of dynamos, ring magnets for transformers, straight laminated cores for induction coils, solenoid cores for automatic circuit breakers, etc.
157. What is electro-magnetism?	It is the magnetism produced around a conductor when an electric current flows through it.
158. How prove the presence of magnetism around a conductor through which a current of electricity is flowing?	Send an electric current through a bare copper wire and plunge the wire into iron filings. The filings are attracted to all sides of the wire, as though it were a magnet. The attraction will be equal on all sides of the wire. When the circuit is broken, the filings drop off the wire.
159. What manifestations are produced if a wire through which a current of electricity is flowing be run through a piece of paper having iron filings on it? What does it prove?	The filings will arrange themselves in concentric circles around the wire and at right angles to it. This proves that the lines of force due to a wire carrying a current are circular and are sometimes known as magnetic whirls. These lines of force do not merge into, cross, or cut each other, but complete their circuits independently around the wire.
160. How tell the direction of the flow of current along a conductor?	By determining the direction of the magnetic whirls around the conductor. This is done with a compass. Place the compass under the conductor and *When a current flows from North Over* a *compass needle to South the n–end is deflected East*. This may be remembered by the combination of the above-printed initial letters *NOSE*. The converse of this statement is also true. When a current flows from *South* to *North Over* a compass needle the n–end is deflected *West*. This combination of printed initial letters forms the word *SNOW*. The converse is also true.
161. What is a solenoid?	A solenoid is a coil of wire, generally wound on a wooden or brass spool, the length of which is much greater than the diameter. The winding is always in the same direction, layer upon layer, similar to the winding of a spool of thread. Upon the passage of a current of electricity through the coil of wire of a solenoid it becomes a powerful magnet.
162. Where is the magnetic attractive force of a solenoid utilized?	Where a long pull is required, such as for operating circuit breakers, firing guns used for morris tube practice, operating semaphore arms, operating the valve for whistles, etc., and may be used for measuring current and pressure.

ELECTRICITY—Continued.

MAGNETISM—Continued.

Question.	Answer.
163. How is a long pull produced by a solenoid?	A soft iron bar called a solenoid core, which becomes an electro-magnet, is placed so that it will freely enter the solenoid. If a current be sent through the solenoid, it becomes a powerful magnet, the soft iron core becomes an electro-magnet and will move so that it will embrace the greatest number of lines of force which are in the center of the solenoid. The longer the solenoid the longer the pull.

ELECTRO-MAGNETIC INDUCTION.

164. What is meant by electro-magnetic induction?	If a wire be arranged so as to form a closed circuit and then moved across a magnetic field, a current of electricity is produced in the wire; in other words, if we artificially produce around the wire the magnetic whirls, a current of electricity flows through the wire when the circuit is complete. Currents so generated are known as *induction currents*, and the act of producing them is termed *electro-magnetic induction*.
165. How are induced currents classed?	(*a*) Magneto-electric induction. (*b*) Electro-magnetic induction. (*c*) Mutual induction. (*d*) Self-induction.
166. What is magneto-electric induction?	In magneto induction a permanent magnet is used to produce the magnetic field, and either the wire or the field may be moved to produce induction.
167. What is electro-magnetic induction?	In electro-magnetic induction the magnetic field of a current is used to produce the magnetic field, and either the wire or the field be moved to produce induction.
168. What is mutual induction?	The induction due to 2 independent electric circuits reacting upon each other is called mutual induction.
169. What is self-induction?	Self-induction is the cutting of a wire by the lines of force of the current flowing through it. When a current begins to flow along a wire the magnetic whirls spring outward from the wire and cut it. This cutting of the wire by its own lines of force induces in it a momentary inverse or counter E. M. F. The effects of self-induction are more noticeable in a wire coiled up, as in a helix or solenoid, or the coils in a motor armature.

ELECTRICITY—Continued.

ELECTRO-MAGNETIC INDUCTION—Continued.

Question.	Answer.
70. What is the law of induced currents?	Lenz's law, which is: *In all cases of electro-magnetic induction the direction of the induced current is such as to tend to stop the motion producing it.*
71. Give an explanation of this law.	To produce the induced current, energy must be expended in bringing the magnet to the coil and in taking it away. If the magnet is made to approach by hand, muscular energy is expended; if a coil or coils of wire are revolved in a magnetic field, as in a dynamo, a steam engine supplies the power and mechanical energy is expended, and it is in this way that *mechanical energy is converted into electrical energy in the* dynamo. More mechanical energy must be expended in proportion to any increase of electricity desired.

INSTRUMENTS FOR MEASURING CURRENTS.

72. What is a galvanometer?	An instrument which measures a current of electricity by its electro-magnetic effect is called a galvanometer. Galvanometers may be used for detecting the presence of an electric current in any circuit, and for determining its direction, strength, and pressure.
173. Upon what principle is their construction based?	On the principle that a magnetic needle, or its equivalent, is deflected when brought under the influence of a magnetic field, such as that of a wire through which electric current is flowing.
174. Describe a simple galvanometer.	Consists essentially of a magnetic needle poised or suspended in the center of a coil of wire, and provided with a circular scale, graduated in degrees, on which the deviation or deflection of the needle may be noted.
175. How does such an instrument detect the presence of an electric current?	When connected in a circuit in which an electric current is flowing, the needle is deflected, due to the needle turning to receive through itself the greatest number of lines of force.
176. How does it show the direction and strength of an electric current?	The direction of the current is shown by the side toward which the n-pole of the needle moves. (See answer to question No. 160.) The strength of the current is indicated by the amount of the needle's deflection.
177. What is an ammeter?	An ammeter, which is the commercial name for an ampere meter, is a galvanometer, designed to show by direct reading the number of amperes of current flowing through any circuit in which it may be inserted.

ELECTRICITY—Continued.

INSTRUMENTS FOR MEASURING CURRENTS—Continued.

Question.	Answer.
178. Give a brief description of a Weston ammeter.	A permanent horseshoe magnet is fitted with soft iron pole pieces, between which a stationary cylinder of soft iron is supported by a piece of brass extending across the pole pieces. The iron cylinder is smaller in diameter than the bore of the pole pieces, so that the magnetic lines of force pass across this air gap, making a strong and uniform magnetic field. The movable system consists of a rectangular coil of wire, wound upon a bobbin of thin sheet copper or aluminum, and delicately suspended between jewel bearings. A thin aluminum knife-edge pointer is attached to the bobbin and swings over the scale and indicates the angle of deflection of the coil. This coil is mounted concentrically with the iron cylinder and pole pieces in the air gap.
179. How is the movable system electrically connected?	The terminals of the coil are connected to 2 horizontal spiral springs against which the coil acts when it tends to rotate, the springs serving to also conduct the current to and from the coil.
180. Explain how an ammeter registers or indicates the number of amperes flowing through a circuit.	When a current is sent through the movable coil, by the spiral springs, the coil tends to move through the magnetic field, to take up a position so that its lines of force will be in the same direction as those of the field. It will so move until the torsion of the springs is balanced by the force tending to move the coil, when the pointer will indicate the angle of deflection.
181. How is an ammeter connected up?	In series. Only a small portion of the total current to be measured is sent through the movable coil, the remainder passing through a shunt. The instrument is however graduated to read directly the total number of amperes.
182. What care should be observed with the ampere shunt?	The lead wires to the shunt, the instrument, and the shunt are all numbered to correspond, so that when used together the indications agree with the calibrations. The shunt leads must never be shortened, because the decreased resistance in the shunt circuit would permit more current to flow through it, so that the indicated readings would be higher than the actual current flowing.
183. What is a voltmeter?	A voltmeter is a galvanometer designed to show by direct reading the number of volts pressure, or the difference of potential in any circuit.
184. Give a brief description of a Weston voltmeter.	The same construction is employed in this make of voltmeter as in the Weston ammeter. (See answer to question No. 178, extra resistance being connected in series with the movable coil and the terminals brought out to binding posts.)

ELECTRICITY—Continued.

INSTRUMENTS FOR MEASURING CURRENTS—Continued.

Question.	Answer.
385. How is a voltmeter connected up?	Voltmeters are connected directly across the line, the potential drop of which is required, or in parallel with the conductor between the ends of which the voltage is required.
386. What is meant by potential drop in a circuit?	By the expressions "potential drop," "fall of potential," or "volts lost" in any part of a circuit is meant that portion of the E. M. F. which is used in causing the current to flow between the two points considered and is due to resistance.
387. What is a Wheatstone bridge?	An instrument for measuring resistance.
388. Give a brief description of a Wheatstone bridge.	A compact wooden box containing a set of resistance coils of platinoid wire, a battery of 4 dry cells, and a galvanometer. The coils of platinoid have terminals connected to brass blocks, and the current is short circuited from going through the coils, by placing in or removing brass plugs between the brass blocks. The resistance of each individual coil is stamped beside the space between the brass blocks to which the coil is attached. Suitable terminals supply means for attaching the wire, the resistance of which is to be measured. The battery circuit and galvanometer circuit are each provided with a key.
389. What is the principle of measuring resistance with a Wheatstone bridge?	Sending a current from the battery through the resistance coils and the wire to be measured. The plugs are so placed until the same amount of current passes through them as through the wire to be measured; or, in other words, the resistance of the coils is equal to or balances with the resistance of the wire being measured, as shown by the galvanometer. Read off the resistance by adding the figures opposite the spaces unfilled by plugs. (Note.—In some bridges the resistance is plugged in and in some the resistance is plugged out.)
390. Name another method of measuring resistance?	The "drop of potential" method.
391. Describe the fall of potential method of measuring resistance?	Consists of passing a current through the conductor to be measured and measuring the amperes flowing by an ammeter, and with a voltmeter find the drop in volts through the conductor. The resistance is then calculated from Ohm's law $R=\frac{E}{C}$.

ELECTRICITY—Continued.

DYNAMOS.

QUESTION.	ANSWER.
192. What general type of dynamos are used in the service?	Direct current, constant potential, multipo compound wound.
193. What is a dynamo?	A machine by which mechanical energy c verted into electrical energy.
194. How is this accomplished?	By means of electro-magnetic induction.
195. Give the elementary theory of how a dynamo generates electro-motive force.	If a loop of wire or conducting circuit be plaed a magnetic field and then revolved so tlt magnetic lines of force in the field are cut tor or interlinked with the said loop of we, E. M. F. will be indueed in the loop or rc proportional to the rate at which the nm of lines of force are altered.
196. Does a dynamo create electricity?	No. It generates or produces an induced ect motive force which causes a current of elecic to flow through a properly insulated sysm electrical conductors external to it.
197. Is a current of electricity generated in a loop of wire if there is no change in the number of lines of force flowing through it?	No.
198. How may dynamos be classed according to their design and mechanical construetion?	Direct-current machines and alternating-cr machines or alternators.
199. What is meant by direct current?	This refers to the current in the external circu a means that the current there flows in one d n direction.
200. What is meant by alternating current?	This refers to the current whieh is reversed, a h intervals, so rapidly that it appears to b cc stant in the circuit.
201. What kind of current flows in the coils of the armature of a dynamo?	All dynamos induce alternating current in h armatures.
202. How is this alternating current converted into direct current in direct-current machines?	By means of a commutator on which a slidin cc tact is maintained by brushes of conductir m terial.
203. How is an alternating current sent out in the external circuit?	By means of collector rings, on which a slidin co tact is maintained by brushes of conductin m teriai.

ELECTRICITY—Continued.

DYNAMOS—Continued.

Question.	Answer.
204. Name the principal parts of a dynamo.	Base, frame, pole pieces, armature, core, commutator, brushes, brush holders, and field coils.
205. Describe the armature.	Consists of a core of a number of thin disks of soft sheet iron or steel, insulated from each other, and securely keyed to the armature spider. The armature windings, consisting of bars of copper or copper wire well insulated inserted in slots of the core, form the closed coils, the ends of which are secured to their proper commutator segments.
206. What is the function of the armature?	To revolve in the magnetic field of the field magnets, thereby inducing a current to flow in its closed coils as these coils cut magnetic lines of force.
207. What are binding wires?	After the armature is completely wound the conductors are secured by binding wires, placed at equal distances along the length and bound around the circumference of the armature. These wires are to prevent the conductors from being shaken loose and racked off when revolving at a high rate of speed.
208. What is the function of the core of the armature?	To provide an easier path for the lines of force from pole to pole of the field magnets.
209. Why is the armature laminated or laid up in disks?	To prevent the flow of eddy currents which have a tendency to heat the armature. These eddy currents in the core do not appear in the external circuit and reduce the efficiency of the dynamo.
210. Describe the commutator.	Consists of a number of bars or segments of hard drawn copper secured to, but well insulated from the shaft and from each other by sheet mica. The terminals of the closed coils of the armature are secured to their proper segments of the commutator.
211. What is the function of the commutator?	To transmit the induced alternating current from the armature windings to the brushes, commuting or causing the currents induced to flow to the external circuit in one and the same direction.
212. Describe the brushes.	They are strips or blocks of carbon or copper held in place by brush holders and make a sliding or wiping contact on the commutator as it revolves, thus picking up or collecting the electric current from the segments of the commutator as they pass under the brushes.
213. What advantage is there in using carbon brushes over metallic brushes?	They lessen friction, reduce wear on commutator, act in a measure as a lubricant and are less liable to spark.

ELECTRICITY—Continued.

DYNAMOS—Continued.

Question.	Answer.
214. Describe the field-magnet frame of a multipolar dynamo, service type.	The frame is of cast steel circular in shape, and is made in 2 pieces, the lower of which is provided with feet by which the frame is bolted to the generator foundation. Holes are made in the magnet frame in which the magnet cores are secured by bolts.
215. Describe the field-magnet cores.	Are of soft steel or iron and are bolted to the inside of the magnet frame. The inner extremities of the poles have a lug of metal bolted to them called pole pieces or shoes. These shoes are quite close to the revolving armature.
216. Describe the field spools.	Are circular in shape, are made of malleable-iron flanges riveted to a sheet-iron body. The spool flange is insulated by maple veneer board collars which are well coated with varnish and shellac. The spool shell is insulated by 4 layers of oiled tape, 2 layers of oiled cotton, and 2 layers of red paper, and a final layer of oiled tape; the spool is then ready for the field windings.
217. Describe the field windings of a multipolar compound dynamo, service type.	The series winding is wound on the spool first and consists of a few turns of sheet copper in ribbon form; these turns are well insulated from each other. The leads for connection to the adjoining spools are of copper strips, and are brought out next the flange, nearest the armature, being well insulated from the shunt winding. The shunt winding is placed on the spool over the series winding. This winding consists of a number of turns of single cotton-covered copper wire. The shunt leads for connection to adjoining spools are brought out next the flange, away from the armature.
218. Are the field windings for a multipolar dynamo wound in the same direction?	No. Half of them are wound in one direction and the other half in the other or opposite direction.
219. How are the field spools held in place on their cores?	By projecting pole pieces, or shoes, upon the cores which are bolted to the magnet frame.
220. What constitutes the field magnets?	The magnet cores, pole pieces or shoes, and the field windings, the whole constituting an electromagnet.
221. Where is the magnetic field of a dynamo?	Between the poles. The space occupied by the armature, and through which the lines of force flow.

ELECTRICITY—Continued.

DYNAMOS—Continued.

Question.	Answer.
222. An armature of a dynamo can be turned over by hand quite easily; then what is the cause that necessitates an engine capable of an output of 20 horsepower, for instance, to turn the armature when a load is on?	When the armature is moved slowly, the magnetic field is weak. When the armature is revolving rapidly the fields become stronger, due to current passing around the field, which increases the magnetism. This causes a drag on the armature, tending to hold it still, thereby needing an engine to overcome this drag on the armature.
223. What does the E. M. F. of a dynamo depend on?	(*a*) The number of lines of force cut by the armature wires. (*b*) The number of cutting wires. (*c*) The speed at which the lines of force are cut.
224 What are the losses in a dynamo?	Mechanical losses and electrical losses.
225. What are the mechanical losses?	Friction between the rotating armature shaft and its journal bearings andt he friction of the brushes upon the commutator.
226. What are the electrical losses?	Electrical friction or resistance in the armature and field. Magnetic friction or hysteresis in armature core.
227. What is meant by the output of a dynamo?	The available electric energy produced by the dynamo.
228. What is meant by the intake of a dynamo?	The mechanical energy required to run the dynamo.
229. How calculate the efficiency of a dynamo?	$\text{Efficiency} = \frac{\text{output}}{\text{intake}}$.
230. What is meant by "constant-current dynamo?"	One that supplies a constant current or amperage with a variable voltage.
231. What is meant by "constant-potential dynamo?"	One that supplies a constant E. M. F. or voltage with a variable current.
232. How may dynamos be classed according to the manner of their field excitation?	As magnetos, series dynamos, shunt dynamos, compound dynamos, and separately excited dynamos.
233. Describe a magneto.	The field magnets are permanent, and the armature cuts the lines of force due to these magnets.
234. Describe the manner of field excitation of a series dynamo.	The field magnets are connected in series with the armature and wound with a few turns of heavy wire having a low resistance, so as not to oppose the main current flowing through them.

ELECTRICITY—Continued.

DYNAMOS—Continued.

QUESTION.	ANSWER.
235. Describe the manner of field excitation of a shunt dynamo.	The field magnets are connected in parallel or shunt with the armature and are wound with many turns of small wire having a high resistance compared with the armature, since only a small proportion of the main current flows through them.
236. Describe the manner of field excitation of a compound dynamo.	The field magnets contain 2 independent windings—1 of a few turns of heavy wire and connected in series with the armature current, the other with many turns of smaller wire and connected in shunt with the armature, being a combination of series and shunt windings.
237. Describe the manner of field excitation of a separately excited dynamo.	The field magnets are separately excited from an auxiliary dynamo, called an exciter.
238. What kind of dynamos require an exciter?	Alternating-current dynamos, since the alternating current can not be employed to excite the field.
239. What other method may be employed to excite the field of an alternating-current dynamo?	Separate coils wound on the armature are connected to an independent commutator, which furnishes current for the field magnets.
240. How is current generated in a new dynamo?	By magnetizing the field. This is accomplished by current from an outside source being sent through the field.
241. What is residual magnetism?	If the soft iron or steel cores of a dynamo have once been magnetized, they retain a small amount of their magnetism. This is called "residual magnetism."
242. What is meant by "building up the fields of a dynamo?"	By starting a dynamo and sending a current around the field; this current being generated by the residual magnetism gradually "builds up" the magnetism of the field until the maximum voltage is attained.
243. What is the usual method of regulating and controlling the current required for various electrical purposes?	By inserting resistance, or taking it out of a circuit. It will be seen by Ohm's law, $C=\frac{E}{R}$, that if the pressure (E) is constant the current C can readily be regulated by increasing or decreasing R—that is, by changing the resistance in circuit.
244. What apparatus is used for changing the resistance of a circuit?	A rheostat.
245. What is the function of a rheostat?	To absorb electrical energy.

ELECTRICITY—Continued.

DYNAMOS—Continued.

Question.	Answer.
246. Describe a rheostat.	Generally consists of a number of coils of German-silver wire of high resistance, insulated by a coat of enamel or porcelain and contained in a well-ventilated fireproof receptacle. The terminals of these coils are brass or copper buttons. Each set of coils may be cut in or out at will by moving a metallic connecting arm over the buttons or segments, and the resistance is thus readily adjusted.
247. How is the rheostat connected up for regulating the E. M. F. of a compound dynamo?	In series with the shunt field winding.
248. Explain how the E. M. F. is regulated.	By placing resistance in the shunt field winding. This sends a less amount of current around the field by way of the shunt winding, which decreases the magnetism, which in turn decreases the voltage of the dynamo.
249. What is meant by "overcompounding?"	If a greater amount of current is sent around the series field coils than is required at all loads, the voltage will rise as the load is increased. The dynamo is then said to be "overcompounded."
250. How is the series field adjusted to counteract overcompounding?	By placing resistance in the series field. This consists of a "German-silver shunt" in parallel with the series field. The length of the shunt is regulated to send a certain amount of current around the series coils to produce the desired compounding. When adjusted it is not necessary to alter it.
251. What is a switchboard?	A center of distribution for control of electrical energy.
252. How are switchboards generally constructed and fitted?	They are constructed of slate or marble slabs, on which are mounted copper bus bars, to which are attached the various main and feeder wires; the instruments for indicating volts, amperes, and grounds; the rehostats for controlling shunt field resistance of dynamos; the magnetic circuit breakers and fuses for protecting dynamos from overload or short circuits.
253. Name the bus bars on a switchboard?	Positive lighting, positive power, positive searchlight, and 1 common negative; 2 equalizer bars, 1 for power and 1 for light. Switchboards sending power to electrically turned turrets have, in addition, a positive bus bar for each turret.
254. What is the reason for having one common negative bus bar?	To save material and space and allow the negative leads of each machine to be connected to a common center by a single-throw, single-pole switch.

ELECTRICITY—Continued.

DYNAMOS—Continued.

Question.	Answer.
255. How are the positive bus bars arranged and place?	There are as many vertical, generative bus bars as there are dynamos. At the back of these and crossing but not touching them are the horizontal bus bars. These may be connected to the vertical bus bars by single-pole, single-throw switches, which allow each, any, or all dynamos to be connected to each, any, or all circuits.
256. What are the equalizer bars? Describe action of them.	They are the bars that parallel dynamos, allowing 2 or more dynamos to divide the load through this path of conductivity between them.
257. What is a switch?	A mechanical contrivance that opens or closes a path of conductivity.
258. Name the principal switches on a switchboard.	Positive power, positive lighting, positive searchlight, positive turret turning and common negative, dynamo field switches. These may be used for separately exciting shunt field of any one dynamo to operate any one turret.
259. Describe a circuit breaker.	Is a mechanical form of switch having an electromagnetic release or a mechanical release with a magnetic tripper. It is designed to release or trip, opening the circuit by an overload or short circuit on the line. The magnetic coils for these circuit breakers receive their current through shunt leads that carry part of the current, but not enough to allow magnets to have their full strength on an overload or short circuit comin on the line. These shunt leads get more current, which increases the magnetic strength or pull of the magnets through space, thus releasing tripper and opening the circuit.
260. What are fuses?	A composition metal alloy in form of wire, clips, or cartridge shape.
261. What is the function of a fuse?	Being put into and made part of a circuit or conductor it is designed to fuse or melt when a certain safe carrying capacity of the circuit is exceeded, thus breaking the circuit.
262. How is a voltmeter connected on a switchboard?	The voltmeter connections are made across the horizontal line of positive bus bars, in parallel with the common negative bus bar. By means of a receptacle plug cut out in the connection to positive bus bars the voltage of any dynamo may be read.
263. How are ammeters connected on a switchboard?	Each dynamo has its own ammeter, which is connected in series with the dynamo bus bar. Only a small portion of the current to be measured is

ELECTRICITY—Continued.

DYNAMOS—Continued.

QUESTION.	ANSWER.
	sent through the instrument, the remainder passing through a shunt. The ammeter is, however, graduated to give the direct reading in amperes.
4. What is a ground detector, and how are they connected up?	It is for detecting at any time while circuits are on whether the line is grounded. It consists of 2 lights in series, one terminal connected to the positive bus bar and grounded, and the other terminal connected to the negative bus bar and grounded.
5. How detect a ground?	The ground detector lamps burn ordinarily at reduced candlepower but with equal brilliancy. If a ground comes on either the positive or negative line, one lamp will brighten up, due to the current from the ground.
6. How locate a ground?	Cut out circuit switches until ground fails to show on the detector lamp. The one cut last will be the circuit on which the ground is located.
7. Name another way of detecting a ground.	Switchboards are fitted with ground detector voltmeter connections.
8. Describe its connections?	An ordinary switchboard voltmeter is connected to a switch group, where positive legs from each power and lighting bus bar and common negative bus bar have connection through voltmeter to ground.
9. How start a dynamo?	See that dynamo and engine are all right. Open exhaust and cylinder drains. Crack by-pass. See that oil service is operating. When cylinders are warm crack throttle and continue to jack engine over by hand until all parts are warm, then open throttle and bring engine gradually up to speed. Close drains and by-pass. Regulate voltage by rheostat and close dynamo switches and circuit breakers. Cut in the circuits as needed.
0. How stop a dynamo?	Take off all the load, open switches and circuit breakers, slow down engine, gradually bringing it to rest. If lubrication is not of the automatic forced type, stop oil feed.
1. If load is too much for one dynamo already running, how connect another dynamo in parallel?	Start up second dynamo. After its speed and voltage are regulated, first, close circuit breaker; second, close equalizer switch; third, close switch to common negative; fourth, plug to voltmeter and adjust voltage by field rheostat; fifth and last, close positive switch.

ELECTRICITY—Continued.

DYNAMOS—Continued.

Question.	Answer.
272. Explain how 2 dynamos connected in parallel equalize the load between them?	The series fields of both dynamos are connecte through the equalizer and if the speed of eith dynamo falls, thereby lowering its voltage, cu rent from the stronger dynamo will flow throug the equalizer and build up the series field of th weaker dynamo, thus increasing its voltage.
273. Can more than 2 dynamos be connected in parallel?	Yes; if their voltages are the same.
274. Two dynamos are connected in parallel. How disconnect one of them?	In shutting down a dynamo in parallel with anothe trip circuit breaker; open bus bar switches; ope equalizer switch; turn rheostat, throwing out re sistance; when voltmeter is at zero open fiel switch, then shut down dynamo.
275. If dynamo is generating "too high voltage," how will same be indicated? State "cause" and "remedy."	Voltmeter reads greater than standard and lamp burn with undue brilliancy. May be due to "to high speed of engine;" if so, "slow the engine," or to "too strong magnetic field," in which cas "introduce more resistance in shunt field" witl rheostat.
276. If dynamo is generating "too low voltage," how will same be indicated? State "cause" and "remedy."	Voltmeter reads lower than standard and lamp burn dimly. May be due to "too low speed o engine," too weak magnetic field, or "brushe not properly set." If due to speed of engine "speed up engine." If magnetic field i weak, "take out resistance in shunt field." I brushes are not properly set, rock brushes bacl and forth on commutator till highest voltage i shown.
277. What are some of the causes of sparking at brushes?	Excessive current, brushes improperly set, rougl commutator, broken circuit in armature or commutator, broken circuit in field winding, dirty commutator, poor brushes, short circuit, or grounc on line.
278. How would "excessive current" manifest itself?	In addition to the sparking at the brushes the ammeter would read too high for the capacity of the machine.
279. How detect a ground in the armature?	Connect all the commutator bars together by wrapping them with a conductor and passing a current through this wire, taking the other leading wire to the iron core. If armature is grounded, current will flow through armature coil grounded to armature core, thus magnetizing the coil in the vicinity of the grounds, and these points can be detected by a small compass needle moved around the armature.

ELECTRICITY—Continued.

DYNAMOS—Continued.

QUESTION.	ANSWER.
280. How detect a break in armature coils?	This can usually be detected by violent flashing on the commutator, the commutator bar nearest the break being burned or cut.
281. How locate a broken coil in armature?	With a magneto. It will not ring through a broken circuit.
282. How detect a short circuit in armature?	A short circuit in the armature usually attracts attention by the smell of burning varnish or shellac. A piece of iron held near a revolving armature with a short-circuited coil will be strongly affected, once a revolution, as the coil passes the iron. When it is discovered that an armature is short circuited, stop the dynamo. The armature should be felt all over by hand. The short-circuited coil will be found to be much hotter than the others.
283. An armature coil is short circuited. What is the remedy?	Rewind the coil.
284. How detect a ground in a field coil?	The effect of a ground in a field coil would cause weak magnetism in the grounded coil, and a piece of iron held at an equal distance between poles will be more strongly attracted by the good one than by the weak. Test by sending a current through suspected coil with a magneto, connect one terminal to terminal of field coil and the other terminal of magneto to ground. If magneto rings, it indicates a ground.
285. How detect a break in a field coil?	If there is a complete break of both the series and shunt windings in a compound dynamo, it will probably refuse to excite. Test by sending a current through suspected coil with a magneto connected to give current through each winding in turn. If magneto does not ring, it indicates that there is a break in winding.
286. How detect a short circuit in field coil?	Would have the same effect on the magnetism of the short-circuited coil as described above for a grounded coil.
287. What care should be observed with a commutator?	See that brushes are properly set on commutator. Keep commutator perfectly clean. Never use emery on commutator; if necessary use fine sand paper, and if absolutely necessary, a dead smooth file. This would only be necessary if commutator was scored or burnt. If badly scored the commutator may be turned down in a lathe. See that no oil is spilled on commutator. If necessary to lubricate commutator smear a small

ELECTRICITY—Continued.

DYNAMOS—Continued.

Question.	Answer.
	amount of vaseline on a strip of canvas and apply it to revolving commutator while brushes are raised. When dynamo is running, the great thing to be borne in mind is that there shall be no sparking on the commutator.
288. What care should be observed with an armature?	Dust and dirt should be prevented from accumulating between coils of armature, and especially copper filings or dust. See that oil is not spilled on insulation of armature cores, as oil rots insulation. Keep armature free from moisture. In removing armature or replacing same in dynamo great care should be observed that insulation or coils are not damaged by rough handling. If by any chance armatures become damp they should be run for some time without load, allowing heat to gradually dry them.
289 What care should be observed with circuit breakers?	The fiber tripping piece connected with the tripping arm may wear and have to be replaced.
290. How adjust tension of spiral spring of circuit breaker?	If the spring has too little tension the toggle is liable to unlock, owing to vibration or when jarred by concussion. If the spring has too much tension, it may resist the action of the tripping arm so the breaker will not open at the desired current.
291. What care should be observed in closing circuit closers?	Always throw 1 circuit breaker at a time. If fitted with independent switches always throw 1 switch at a time, and never close one while holding the other. Always throw a switch till it is securely locked. Never open it slowly, as the contacts are apt to be burnt.
292. What care should be observed with circuit switches?	Circuit switches should be thrown quickly in either direction to prevent arcs being formed which injure the contacts. When opened, the switch should be fully opened and the blades not left near the clips.
293. What care should be observed before opening the field switches of dynamos?	Throw the field rheostat to "low" and open when voltmeter stops moving toward zero.
294. What care should be observed in opening "turret field switches?"	They should be opened slowly to allow the induced current of the motor field to discharge through the field resistance.

ELECTRICITY—Continued.

MOTORS.

Question.	Answer.
295. What is a motor?	A machine by which electrical energy is converted into mechanical energy. The electrical energy going in at the commutator turns the armature, which gives off mechanical energy.
296. How does a motor differ from a dynamo?	In a dynamo the armature is turned by mechanical energy and electrical energy is delivered from the commutator. In a motor electrical energy is supplied to the commutator which turns the armature; this turning is the mechanical energy given off by the motor.
297. What causes a motor armature to revolve?	A conductor carrying a current will, when placed in a magnetic field, tend to move in such a direction as to embrace the greatest number of lines of force.
298. Can a dynamo be used as a motor?	Yes.
299. What is "torque?"	"Torque" is the twisting force that turns the armature, and is produced by the reaction of the field of the armature upon the magnetic field of the motor.
300. How may motors be classed?	The same as dynamos. (See questions and answers, Nos. 230, 231, 232, 233, 234, 235, 236, 237.)
301. How are compound motors classed?	According to the manner of their field excitation, there being accumulative field windings, and differential field windings, and one in which the motor armature excites its own field.
302. What is meant by "accumulative winding?"	An "accumulative" wound field is one where the series field is wound on the field magnet so that the current passing through it sends the lines of force in the same direction as those set up by the shunt field winding. In other words, the shunt and series windings on each spool are wound in the same direction. This increases the density of the magnetic field.
303. What is meant by "differential winding?"	A "differentially" wound field coil is one where the series field is wound in the opposite direction to the shunt field, or so arranged that the current in passing through it sends lines of force in the opposite direction to those set up by the shunt field. This decreases the density of the magnetic field, as it takes a certain number of the lines of force of the shunt field to keep the lines of force of the series field overcome, consequently weakening the field.

ELECTRICITY—Continued.

MOTORS—Continued.

QUESTION.	ANSWER.
304. What other method of field excitation of motors used on board ship?	Separately excited motors, their fields being excited from sources other than the supplying source.
305. Describe the windings of motor armature that excites its own field.	The armature has two separate circuits, one to receive the supplied current and the other acting as a generator, inducing its own current and which is connected to the series windings.
306. For what kind of work are series motors used?	A "series" motor is used where a heavy starting "torque" (twisting force) is required, as on hoists, such as ash hoists, boat hoists, ammunition hoists, or where there are wanted both variation in the load and speed.
307. For what kind of work are shunt motors used?	"Shunt" motors are used where nearly a constant speed is necessary, such as on portable fans or ventilating sets, or running pumps, and on machinery where there is not much starting and stopping, or where excessive "torque" is not required at starting.
308. For what kind of work are "compound" accumulatively wound motors used?	"Accumulatively" wound motors are used where a great twisting force (torque) of a series motor is required, combined with the steady running of the shunt motor.
309. For what kind of work are differentially wound motors used?	"Differentially" wound motors are used where a constant speed is required and the load on the motor is constantly changing.
310. Will a series dynamo run in the same direction when run as a motor?	No. It will run in the opposite direction.
311. Will a shunt dynamo run in the same direction when run as a motor?	Yes.
312. To change the direction of motion of a motor do you change the direction of the current in both the field windings and armature?	No. To change the direction of motion of a motor either change the direction of current in the field coils or change the direction of current in the armature, but not in both.
313. What kind of a device is used for doing this, and where is it connected up?	A reversing switch is used to change direction of motion of a motor, and it is either connected in the field circuit or the armature circuit.
314. What kind of motors are used in "the turret training system?"	Two motors connected in series. These motors are separately excited.

ELECTRICITY—Continued.

MOTORS—Continued.

Question.	Answer.
315. How are these motors separately excited?	By a current passing around their fields, which is derived from the power bus bars on the switch-board in the dynamo room, this current being controlled by a turret field switch.
316. How are dynamos arranged to supply current to turret-turning motors?	The series field of the dynamo in use is shunted by a switch of low resistance on the headboard, or on the switch board, which allows only a portion of the dynamo current to flow through the series coils. The shunt field of the dynamo is disconnected from the dynamo current, and is then supplied with current and is separately excited from the power bus bars, being regulated by a controller in the turret under charge of the one training the turret.
317. Describe the connections between the dynamo and the turret-turning motors.	The leads from the brushes on the commutator of the dynamo are connected to the terminals of the motors, through the turret controller.
318. How is the speed of the turret-turning motors regulated?	The speed of the motors is directly proportional to the E. M. F. at the motor terminals, or at the dynamo terminals.
319. Explain how the E. M. F. at the motor terminals is regulated.	Since the dynamo is rotated at a constant speed, the E. M. F. at its terminals is proportional to the field excitation. Consequently when the strength of the dynamo field is varied the E. M. F. of the motor terminals varies. The field of the motors are constantly excited, their speed being directly proportional to the E. M. F. delivered to their terminals.
320. How is the E. M. F. of the dynamo regulated?	By resistance in the turret controller. By turning the operating handle of the controller resistance is placed in or taken out of the shunt field coils of the dynamo.
321. How is the direction of the turret-turning motors reversed?	The leads to the motor terminals are reversed by means of the turret controller.
322. When the turret controller is in the off position, what causes the motors to stop?	The armature of the motors are short-circuited.
323. How does this affect the motors?	The momentum of the turret may turn the motors and they would generate current, the reversal of which would act as an electric brake absorbing the energy of the moving turret.
324. Can a dynamo used for turning a turret be used for other purposes when so employed? Why?	No; because its voltage is not constant.

ELECTRICITY—Continued.

MOTORS—Continued.

Question.	Answer.
325. What system will allow the main generator to be used for other purposes than simply turning a turret?	The motor-generator system.
326. Give a brief description of the "motor-generator system" of turning turrets.	A motor generator is interposed between the dynamo and the turret motors. The motor end of the generator receiving current from the power bus bars in the dynamo room, it performs the function of a steam engine running a dynamo. The generator end of the motor generator performs the same function in turning the turret that the main dynamo does under the other system, so it must be run at a constant speed in a field which can be controlled in the turret. This system allows the main generators to be used for other purposes than simply turning a turret.
327. What is a motor-generator set?	It is a motor and a generator connected together on one common shaft, so that the motor runs the generator.
328. What apparatus is used to start a motor?	A starting rheostat.
329. What is counter electromotive force?	It is the E. M. F. which is set up in the conductors of the armature of a motor, when it is revolving in a magnetic field, and it tends to or does oppose the applied E. M. F. to a certain degree.
330. From what causes will a motor not attain a high enough speed?	An overload; weak magnetic field when heavily loaded; short-circuits or grounds in armature and too low voltage at the terminals.
331. From what causes will a motor attain too high a speed?	Too light load (in series motors); weak magnetism (if lightly loaded); too high voltage.
332. How remedy low speed of a motor?	Reduce the load, or increase the voltage at the terminals. Stop motor and test for grounds or short-circuits. If there, remove them.
333. How remedy high speed of motor?	Increase the load or reduce the voltage at the terminals.
334. How regulate the speed of a motor?	The speed is regulated by a device consisting of a series of resistances that can be varied at will, and is called a rheostat.
335. What is a starting rheostat?	A starting rheostat is placed in the circuit before the current enters the armature of the motor, and is used to keep a heavy current from flowing through the armature before it reaches a high speed. It is cut out gradually (the resistance) as the motor speeds up and the resistance is entirely out when motor reaches full speed.

ELECTRICITY—Continued.

SEARCHLIGHTS.

Question.	Answer.
336. What is a searchlight?	The application of the arc light to the focus of a reflecting mirror in an inclosure giving a parallel beam of light.
337. What is an arc light? What is its principle?	The oldest form of electric light known. If two carbon points, forming part of a closed circuit in which a current of electricity is flowing, be separated a short distance and the current is strong enough, a spark will jump from one to the other.
338. How is this explained?	The current passing from one carbon to the other is suddenly arrested when the carbons are separated, meeting with a great resistance—that of air between the points. The current continues to flow, causing the carbon to practically boil and the vapor thus arising, being a much better conductor than air, conducts the current from one carbon tip to the other.
339. How does this effect the carbons?	The carbons waste away, and a cup-shaped depression, termed the *crater*, is formed in the positive carbon, while the tip of the negative carbon has a conical form.
340. From where is the light of the arc emitted?	Principally from the *crater* or hollow-shaped cavity in the positive carbon.
341. Upon what does the light depend?	Upon the temperature of the boiling point, or, more properly speaking, the temperature of the vaporization of carbon, which is said to be 3,500° C.
342. How are carbons made?	Of graphite, a powdered form of carbon deposited on the inside of the retorts used in the manufacture of coal gas. It is mixed with a sirup to make the particles adhere firmly and then molded into proper form and baked hard. The center of the carbon is of a softer carbon than the outside. The finished carbons are given a thin electro-plating of copper.
343. Why are the carbons constructed with a soft core?	The soft core having less resistance than the outside tends to hold the current nearer the center, facilitating the first formation of the crater in the center and holding or keeping it there.
344. Why are the carbons electroplated?	To increase the conductivity of the carbon.
345. Are the positive and negative carbons the same size? Why?	No. The positive carbon is the largest. On account of the boiling or vaporization of the positive carbon it wears away about twice as fast as the negative carbon.
346. How is the negative carbon worn away?	By the incandescent particles of carbon from the positive carbon being thrown against it.

ELECTRICITY—Continued.

SEARCHLIGHTS—Continued.

QUESTION.	ANSWER.
347. What is meant by regulating the arc?	To light or strike the arc, the carbons must touch, and at the instant current flows must be separated the proper distance, called the distance of arc, and thereafter gradually approach toward one another or one toward the other as the carbons wear away.
348. How is this accomplished in a searchlight lamp?	By means of the automatic feed.
349. Describe the action of the automatic feed.	As the distance between the carbons increases the resistance increases, which causes a part of the current to shunt through a magnet, which attracts an armature, causing a pawl to actuate a ratchet wheel, which causes the carbons to move together until the proper distance is reached; the magnet then fails to operate.
350. How is the automatic feed regulated?	The feed-magnet armature works against the tension of a spring, which can be adjusted.
351. Explain the adjustment of the armature-tension spring.	The tension of the spring regulates the difference of potential at which the carbons will feed, for the greater the tension the stronger must be the current, or, in other words, the higher the voltage necessary to attract the armature.
352. If the automatic feed fails to work, what would it be necessary to do?	The automatic switch is closed which breaks the shunt circuit, when the carbons can be fed by turning a spindle, for which a wrench is provided.
353. What is meant by "striking the arc?"	By bringing the carbons together and again separating them. This could be called lighting them.
354. What is meant by a "hissing arc?"	An arc "hisses" when the current is increased beyond the practical limit for the size of carbon and particular length of arc employed.
355. What is a "flaming arc" due to?	A "flaming arc" is due to the distance apart of carbons being too great.
356. How does a "flaming arc" affect the light?	Decreases the light.
357. What is meant by a "normal" or "silent" arc?	When the distance between carbons is such that a point is found where the "arc" burns quietly and steadily, it is termed a "normal" or "silent" arc, and in this condition the light is at its maximum strength.
358. To what is a spluttering sound, produced by the arc, due?	To impurities in the carbon.

ELECTRICITY—Continued.

SEARCHLIGHTS—Continued.

Question.	Answer.
359. How are searchlights connected up on board ship?	In parallel. Generally receiving current from an independent bus bar on the switch board in the dynamo room and sometimes from an independent searchlight panel.
360. What voltage do searchlights require.	From 45 to 50 volts.
361. How is the voltage reduced for use with searchlights?	By inserting resistance in each searchlight circuit.
362. How tell if a searchlight or arc lamp of searchlight is properly connected up?	Allow the current to pass through the lamp for a short time after being turned off. The carbon that retains its glow the longest has received the current from the positive side of line.
363. What is a searchlight projector?	A metal barrel or drum which contains the arc lamp. Its rear end contains a parabolic mirror, its front end is provided with a glass door composed of strips of clear glass. The projector is provided with trunnions which seat on the two arms of the turntable.
364. Describe the parabolic mirror.	The mirror is of the best quality of glass, free from all flaws and holes, with its surface ground to exact dimensions. The back is silvered in such a way as to be unaffected by heat. The glass is mounted in a separate metal frame lined with a nonheat-conducting material to allow for expansion due to heat and to prevent injury from concussion.
365. How inspect the arc, while burning, for the adjustments?	The drum is fitted with peep sights for observing the arc in two planes, in the side by a colored piece of glass and in the top by reflecting prisms. A searchlight having a vertical lamp has also a peep sight in rear and center of projector of colored glass.
366. Why is the glass door composed of strips of glass instead of plate glass in one piece?	The glass strips will stand a shock due to concussion better than a solid glass plate. If a strip of glass is broken it may be more cheaply replaced than a solid glass plate.
367. How is the great heat due to the temperature of the arc given off?	By ventilators in the top and bottom of projector barrel.
368. What is the limit of elevation and depression of the projector barrel or drum?	Seventy degrees above and thirty degrees below the horizontal.

ELECTRICITY—Continued.

SEARCHLIGHTS—Continued.

Question.	Answer.
369. What method of elevating and depressing the projector?	The drum can be rotated on its trunnions by hand or clamped rigidly in any position, and while clamped may be given a slow movement in altitude by turning a small handle in the axis of the pedestal.
370. How is the arc lamp secured in the projector?	On a slide, and can be adjusted to focus by moving it closer to or farther from the mirror by means of a screw spindle, which passes through the projector and screws into a thread cut into the face of the lamp frame.
371. Describe the electrical connections to the arc lamp.	The leading wires pass through the projector to sliding contacts. The positive wire is grounded to the lamp frame, which is thoroughly insulated from the projector. The negative carbon holder is thoroughly insulated from the lamp frame and the negative leading wire is connected to the negative carbon holder through a conductor of flexible copper wire.
372. Describe the turntable.	Consists of a metal base on which are two vertical arms finished at their upper ends with trunnion seats on which is mounted the drum or barrel of the projector by means of its trunnions. The turntable is so designed that it can be revolved freely and indefinitely in either direction or clamped rigid if desired. It contains the contacts for electrical connection with pedestal and the leading wires to drum or barrel of projector.
373. Describe the pedestal.	Is a metal casting which is bolted to the deck or platform and fitted to contain the electrical connections to the turntable.
374. Describe the electrical connections between the pedestal and the turntable to the projector.	The leading wires pass through the deck and inside the pedestal through a switch which is situated outside of pedestal to two contact rings on top of the pedestal. These rings are thoroughly insulated from the pedestal. The current passes from the contact rings on pedestal to two contacts on turntable. These contacts maintain a constant wiping or sliding connection on the rings. The leading wires on turntable are of sufficient length to allow extreme elevation and depression.

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HANDBOOK FOR

SEAMAN GUNNERS

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